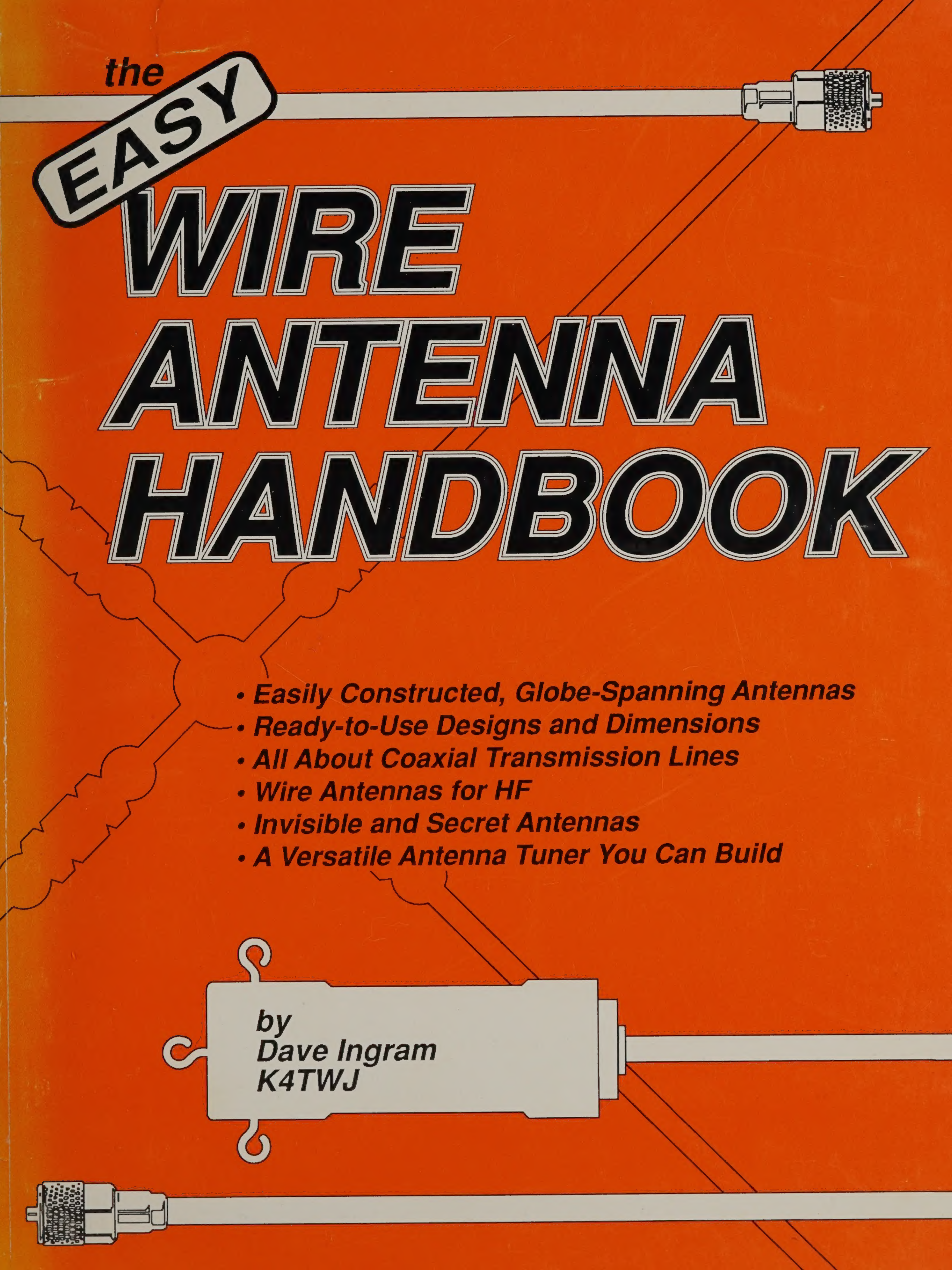

the EASY WIRE ANTENNA HANDBOOK

- Easily Constructed, Globe-Spanning Antennas
- Ready-to-Use Designs and Dimensions
- All About Coaxial Transmission Lines
- Wire Antennas for HF
- Invisible and Secret Antennas
- A Versatile Antenna Tuner You Can Build

by
Dave Ingram
K4TWJ

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The
WIRE ANTENNA
HANDBOOK

By
Dave Ingram
K4TWJ

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THE WIRE ANTENNA HANDBOOK

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PREFACE

What is the easiest and least expensive way to provide your amateur radio setup with globe-spanning capabilities? Use a wire antenna, of course! This book is especially written with that thought foremost in mind, and it provides you with ready-to-use designs and dimensions of wire antennas for all situations or locations. Whether your interests are experimental or sheer enjoyment oriented, whether you are a newcomer or an old-timer, we are sure you will realize almost daily applications for our collection of information and data on wire antennas.

What makes the area of self-assembled wire antennas so popular among radio amateurs? Possibly it is their low cost and flexibility of assembly to fit ones available funds or space, possibly it is their unique performance record in various locations, or possibly it is their informally dubbed "black magic" which creates a common interest which can be pursued by all regardless of technical or financial background. Whatever the reason, there is truly a feeling of personal satisfaction when one turns a few simple insulators and a roll of ordinary wire into a shortwave link with others worldwide. May such rewarding experiences continue forever!

Considering that numerous books and articles are readily available on the technical and theoretical aspects of antennas, this book is primarily directed toward immediately applicable details and measurements for all kinds of wire radiators. It is a reference you can use any time a new sky wire or band of operation is contemplated; plus it includes some "bare bones" radiation facts to help you along the way, now or later.

As you may have noticed in the table of contents, both "basic" and "gain" antennas are given generous coverage. There is also a full chapter highlighting "hidden" or "disguised" antennas for amateurs faced with difficult or seemingly hopeless situations (Awake and enjoy, your time has arrived!). If you need an inexpensive antenna tuner or want to modify your existing tuner for balanced line output, that information is also included, plus "how-to-use" details on SWR meters, noise bridges, sky wires and toroids. Finally, we have included a "common set" of guidelines and formula configurations that can be used to adapt any newly discovered antenna's measurements to your favorite band of operation. We want to insure that you get your money's worth (and more) from this compact publication.

Considerable effort, evaluation, and compilation was involved in this book's assembly, and I thank all the friends who also enjoyed using and testing many of the included designs. A special word of thanks, also, to publisher Tom Harrington, W8OMV, for continuous encouragement on writing this book; Joe Veras, N4QB, for the photographic assistance; and to my XYL, Sandy, WB4OEE, for assisting with the figures and typing this manuscript—a rather massive effort. May each and every reader of this book enjoy strong signals and globe-spanning friendships for many years!

Dave Ingram
K4TWJ
MCMXCII

THE WIRE ANTENNA HANDBOOK

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CHAPTER ONE

ANTENNAS: THE RADIO AMATEUR'S GREATEST ASSET

INTRODUCTION

As any devoted radio amateur will readily attest, an effective antenna system is the single most important item in a station's setup. That radiator may take one of several forms ranging from a basic dipole or vertical to a large array in the cubical quad, log periodic, or parasitic-element Yagi configuration. The prime criterion is always obtaining the maximum achievable performance from an antenna through actual on-the-air operations. Because exceptional technical knowledge or financial support is not vital for home construction and/or experimentation, antennas represent amateur radio's most popular area of pursuit and self-expression. Indeed, most radio amateurs can recall at least one occasion when we quickly assembled some form of wire array for use on a new band or particular area of interest. The exhilaration of successfully communicating hundreds or thousands of miles using antennas personally assembled can truly renew one's pride in being a radio amateur. Need we say more? **See Figure 1-1.**

The unique collection of wire antenna designs and configurations in our amateur world reflect a common area of personal interest which can be enjoyed by experienced operators and newcomers alike. Easily erected horizontal radiators are quite effective for "conventional operations," while vertical arrays can prove to be optimum solutions for limited space situations. Wire beams or phased arrays are desirable for low-investment DXing (Have you ever considered a five-element wire Yagi for 20- or 40-meter operation?), and vee beams or rhombics truly prove their worth for amateurs located in rural areas. The selection of a particular wire antenna is normally dependent upon one's available space, band or bands of desired operation, direction of desired coverage, available funds, and neighborhood visibility. It is truly amazing how radio amateurs can transform a simple roll of ordinary wire into an electronic link with others around the world.

It is interesting to note that the performance of wire antennas in different locations varies almost as much as their many designs. This really is not an invisible form of electromagnetic magic, but rather an explainable phenomenon created by both the antenna and its surroundings. Every radiating sky wire is directly influenced by its height above ground, the ground's conductivity/signal reflectivity, in-field restrictions, and horizon-limiting obstacles. One antenna will be affected by trees and leaves, another will experience soil attenuation, and signals from another will be partially absorbed in certain directions by a hill or building. Every installation is unique.

Figure 1-1 *Wire antennas are the radio amateur's most classic form of self-expression and gratification. They are inexpesively constructed, easily erected, quite inconspicuous (notice balun near middle of picture), and they provide globe-spanning capabilities. May such favorable pursuits continue forever!*

This wire antenna handbook is written in understandable and directly usable form for today's radio amateur. It contains information on all kinds of inexpensive wire radiators—horizontal and vertical, simple and sophisticated. It is oriented as a "hands on" construction guide aimed at helping you achieve the best possible signal transmission and reception with the least effort. Although we obviously cannot describe all varieties of wire antennas (nearly every monthly amateur radio magazine features at least one new antenna idea or design), we will explain simple ways of scaling any antenna's design to any desired frequency. Any antenna of interest can be enjoyed on your own favorite band. That aspect, in itself, almost quadruples this inexpensive handbook's usefulness.

BASIC FACTS APPLICABLE TO ALL ANTENNAS

Although amateur antennas may vary widely in shape and size, each exhibits similar aspects in electrical design allowing them to receive or transmit RF energy. Those aspects may sometimes seem elusive, but they are present and relatively easy to understand. All antennas are effectively tuned AC circuits—electrical open-air versions of tank circuits in transmitter power amplifiers. As such, they exhibit inductance (length of their conductors), capacitance (spacing between conductors and surroundings), and impedance (AC resistance of the system). The majority of amateur antennas also exhibit a resonant frequency of operation—a point where capacitive reactance (X_C) and inductive reactance (X_L) cancel each other, leaving only the surge impedance (Z). Although most antennas are "cut" for a particular center frequency, they can be fine tuned for a certain frequency by a variable coil or capacitor. These components may be part of the antenna (a loading coil to electrically lengthen a physically short antenna or a variable capacitor to electrically shorten a physically long antenna), or they may be included externally (an antenna tuner). Any antenna, however, must utilize a working combination of capacitance, inductance, and impedance to perform effectively.

The performance of any antenna is directly proportional to that sky wire's signal capture area. Antennas of reduced physical size cannot sense or radiate the quantitative millivolts-per-square-centimeter energy of full-sized equivalents. Likewise, antennas with oversized capture areas (more than one- half wavelength) tend to increase millivolt-per-square-centimeter radiation and produce various levels of always-welcomed gain.

Every antenna connects to its related station gear by some form of feed line (usually coaxial cable), and nearly every "properly dimensioned" antenna system tends to exhibit some surroundings-influenced Standing Wave Ratio. This is one reason why two or more amateurs using the same kinds of antennas often experience different results and judge those sky wires accordingly. The enthusiastic amateur, however, will realize that everyone has his own justified viewpoint and that antenna formulas provide approximate dimensioning figures. He might then "tweak" the antenna's length for resonance within a preferred band segment or prune a transmission line for optimum feed-point impedance. This last step has proven quite useful when connecting solid state transceivers without external antenna tuners to various antennas. A mild "juggling" of feed-line length "hits" an impedance point within the rig's output range, and full output from an otherwise "troublesome antenna system" is achieved.

RADIO WAVES AND SIGNAL PROPAGATION

Regardless of how effectively an HF antenna radiates applied RF energy, its capabilities are also directly related to signal propagation by the earth's ionosphere. A certain knowledge of signal-reflecting ionospheric layers, sunspot cycles, and maximum usable frequencies within each seasonal period are obviously vital considerations for successful DX operating results; therefore, a brief overview of those considerations is presented here.

Our earth's ionosphere acts as a variable-density electronic mirror which reflects high frequency signals and permits long distance communications. See **Figure 1-2**. The level of signal absorption or reflection by this unique "hanging mirror" is determined by ultraviolet and cosmic energy bombardment from the sun. As various layers become ionized, they reflect different frequencies in different ways. Generally speaking, frequencies above 14 mHz are best reflected by high sun energy hitting the ionosphere (daylight hours near a signal's mid path) while frequencies below 10 mHz are best reflected when "cooled" away from sun energy (night hours between communicating areas). Those parameters, however, are variable and subject to change with sun angles and degrees of solar energy (seasons of the year and sunspot activities within each 11-year cycle). It is also noteworthy that nearly all HF frequencies approach their optimum levels when "mirror effects" begin and end each day (i.e., dawn or dusk). Those two periods are well known and used by active DXers.

A brief examination of **Figure 1-2** reveals that upper ionospheric layer reflections (F1 or F2) are useful for single-hop, long-distance communications while lower layer reflections (E layer) are useful for shorter distance or multi-hop operations. Also notice the "billiard ball effect" of reflections equalling initial angles. If a radio wave bounces off the ionosphere at a high angle, its first hop will be less than that of a wave hitting the ionosphere at a low angle (a farther distance on the visible horizon). If a signal's first hop returns to earth over water, it will only experience minor attenuation and be reflected skyward again. Land masses, on the other hand, attenuate those signals noticeably. Herein lies many of the secrets to good antenna performance and DXing. Signals leaving an antenna should exhibit a low take-off angle with minimum local and distant ground absorptions. Likewise, signal paths to the ionosphere should be unobstructed in direction and "upward tilt" with respect to the horizon (a high antenna by the seashore would be nice for DXing; a low antenna would be good for "local" operations). Pursuing this combination of "radiator and reflector" a step further, we must also realize that selected frequencies interrelate with sun activity at their particular time of use, and to achieve desired results, the highest "open" frequency or band gives the best results. Understanding these situations, many amateur radio magazines include monthly columns highlighting propagation forecasts. Their charts are beneficial for plotting "open bands and related areas," and for planning what kinds of antennas to use in an amateur station. Two additional propagation resources which should not be overlooked are WWV's hourly forecast at 18 minutes after each hour (5, 10, 15 mHz), and the North California DX Foundation's worldwide beacon network on 14.100 mHz. **See Figure 1-3**. The beacon network is useful for checking signal paths in real time, and for directly comparing antennas or receivers "on the air."

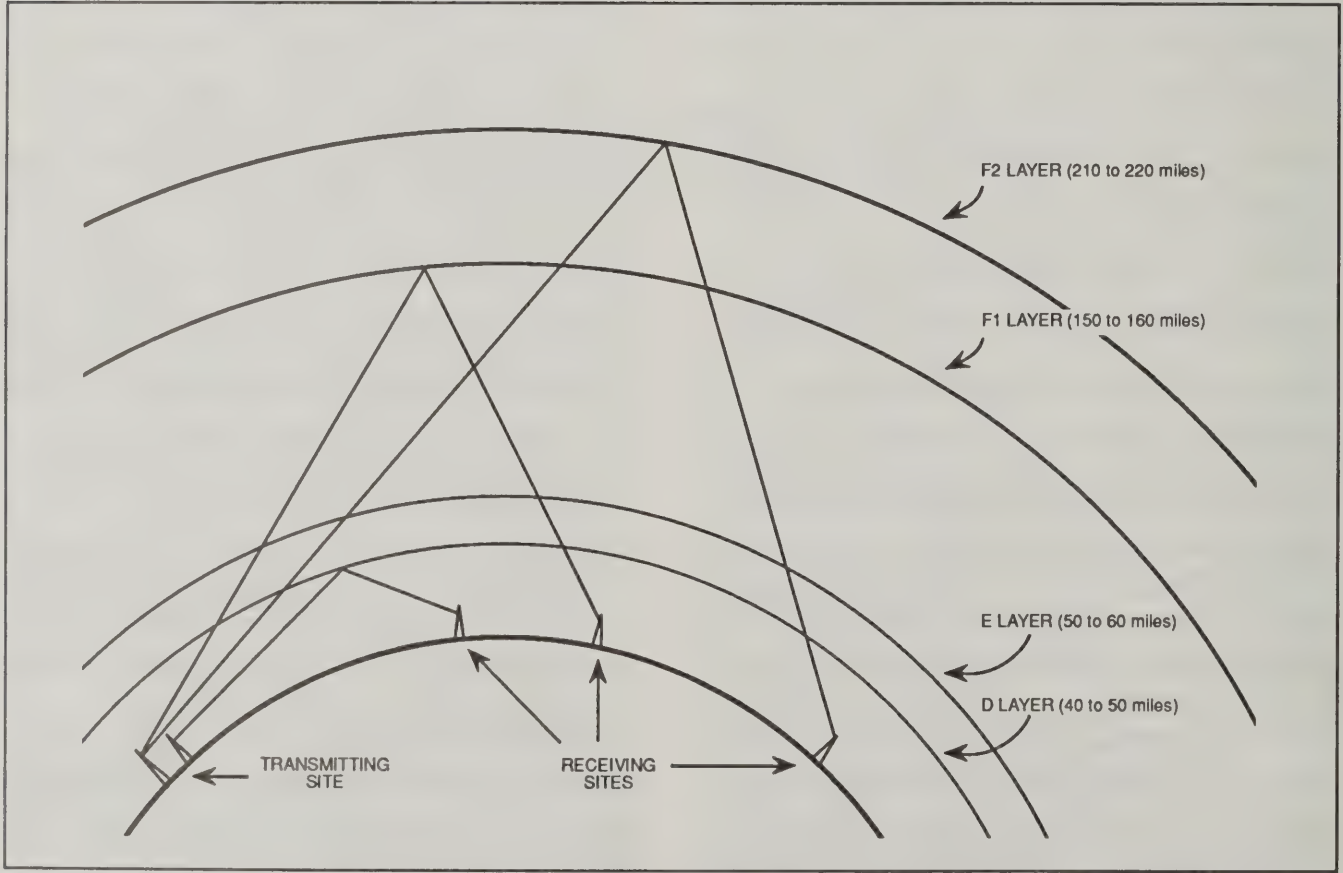


Figure 1-2 *Ionizing layers of the ionosphere and their effects on High Frequency radio communications. Notice signals reflected via the F1 or F2 layers cover noticeably longer distances than those reflected via D or E layers, and that low antenna radiation angles provide the greatest distance-per-hop ratio.*

CONCERNING GOOD GROUNDS

As mentioned previously, transmitted signals are usually attenuated by the earth's soils and reflected by water (especially highly conductive salt water). Applying this fact to amateur radio setups brings to light the importance of a conductive and low-resistance ground system. A portion of any antenna's radiated energy can be absorbed and lost by a poor ground, or favorably reflected toward the ionosphere by a good "mirror imaging" ground. This situation is true for all kinds of antennas, especially ground mounted verticals or random wires which depend upon ground reflections to create the antenna's "missing half." When a basic radiator is secured to a simple four-foot ground rod driven into hard or rocky soil, nearly half of its supplied energy dissipates into the earth. Multiple radials and highly conductive soil below any ground system can reflect some portion of that signal and favorably utilize more of the available watts of power. Regardless of what manufacturers claim or uninformed individuals say, an effective ground system is both signal-beneficial and a vital safety consideration that should not be overlooked.

What comprises an effective ground system? If your antenna system is centered over a marshy swamp, a single six-foot ground rod may be sufficient. Most of us, however, are usually faced with a mixture of "backyard clay and limestone," poor conductors to be sure. How can you improve that situation? Try using several 12- to 16-foot copper coated ground rods placed several feet apart and interconnected by heavy copper strapping. Drive the rods completely into the ground to reach damp soil deep below the surface (try this after a heavy rain to make the job easier). Add as many half-wavelength radials as possible, then connect the full arrangement to outdoor cold water pipes. If you are serious about setting up a good ground system, also consider "seeding" the soil near your antenna with copper sulfate or readily available rock salt. The chemicals only need to be submerged 12 to 18 inches to be effective. Due to erosion, the process will need repeating within three or four years. Cover the completed area with grass and enjoy a ground that is truly "airworthy." **See Figure 1-4.**

SWR METERS AND NOISE BRIDGES

Two of the most useful tuning aids or accessories a radio amateur can own are an accurate SWR bridge/power meter and an antenna noise bridge. The use of these items permits the operator to determine an antenna's effective mating with today's fixed-impedance/broadband transceivers, its resonant frequency, bandwidth, feed-point impedance, etc. Consequent changes to an antenna also can be directly checked and evaluated with a noise and SWR bridge, plus forward power meters can give factual indications whether RF energy is being supplied to the antenna—a very reassuring consideration during extended periods of poor propagation. **See Figure 1-5.**

While most radio amateurs are familiar with SWR bridges and power meters, noise bridges are somewhat less understood in application and use. A noise bridge is a form of non-radiating, antenna-measuring instrument which is used in conjunction with a station's HF receiver. It contains a wide-band noise generator (3 to 30 mHz, typically) and a Wheatstone-type bridge circuit. When connected between an antenna and receiver, S9 noise is heard on all frequencies except that of precise antenna resonance. The bridge's control is then adjusted for a sharp noise null, and the impedance is read on a calibrated scale. Consequent antenna tweakings also can be receiver-checked for exact resonance—and without applying a single watt to the antenna. Many noise bridges include both antenna impedance calibrations and

BEACON SEQUENCE

TIME	STATION	LOCATION
0000	4U1UN/B	UNITED NATIONS, NEW YORK
0001	W6WX/B	STANFORD UNIVERSITY, CALIFORNIA
0002	KH60/B	HONOLULU COLLEGE, HAWAII
0003	JA2IGY/B	JARL, MT. ASAMA, JAPAN
0004	4X6TU/B	TEL AVIV UNIVERSITY, ISRAEL
0005	OH2B	HELSINKI TECHNICAL UNIVERSITY, FINLAND
0006	CT3B	ARRM MADERIA ISLAND
0007	ZS6DN/B	TRANSVAAL, SOUTH AFRICA

Same sequence repeats every 10 minutes. Beacons are crystal-controlled and are on 14.100 kHz. The sequence may vary as more beacons are added to the net.

TEXT TRANSMITTED BY EACH BEACON

POWER LEVEL	CW MESSAGE
100 W	QST de (W6WX/B) beacon
100 W	. ______________ 9-second dash
10 W	. . ______________ 9-second dash
1 W	. . . ______________ 9-second dash
0.1 W	. . . . ______________ 9-second dash
100 W	SK (W6WX/B)

Figure 1-3 *Operating sequence and information content of the North California DX Foundation's Beacon Network which is continuously operational on 14.100 mHz. The system is useful for checking signal paths, comparing antenna reception and patterns, etc.*

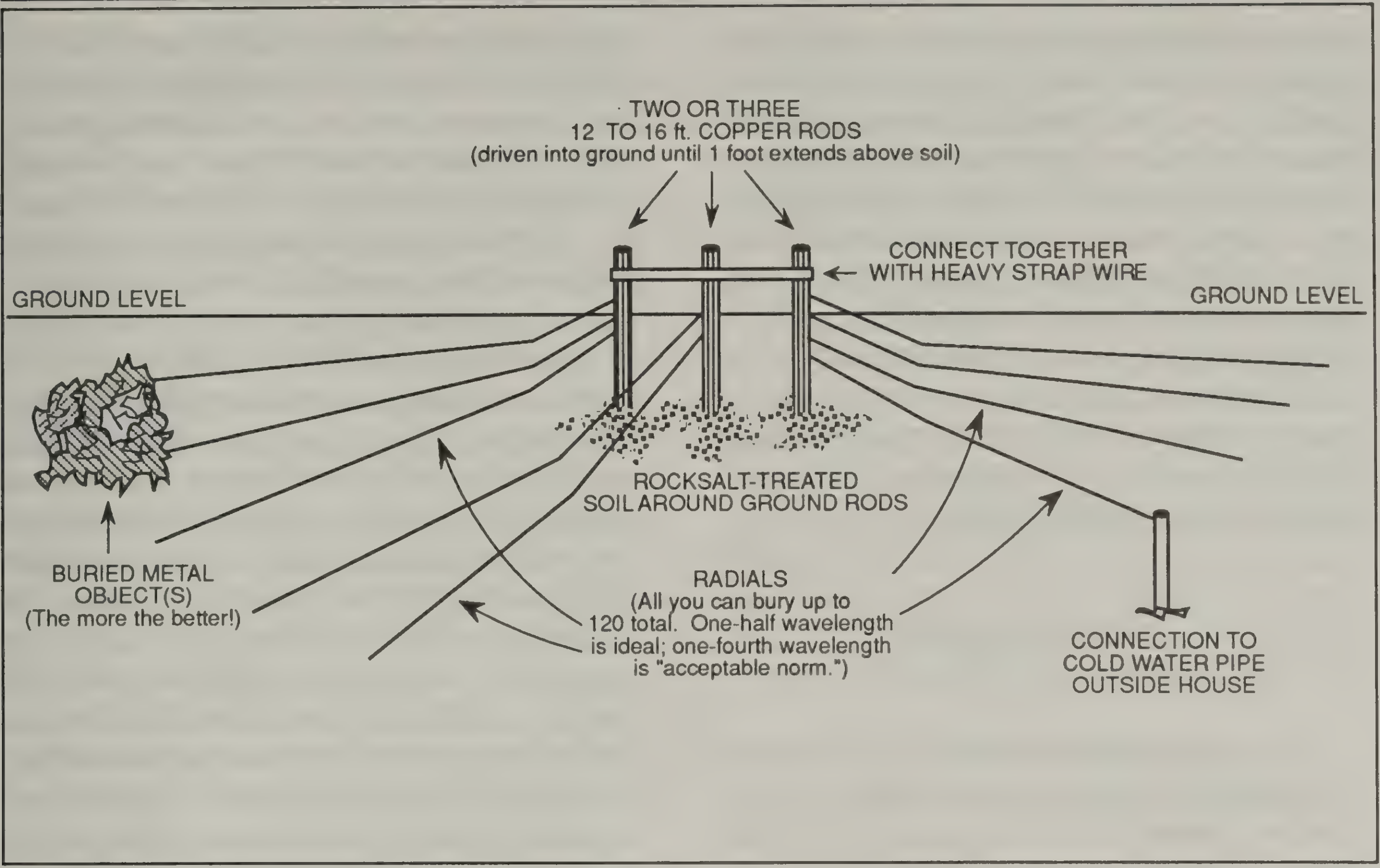


Figure 1-4 *General concept for creating a truly "airworthy" ground system which will improve the performance of any amateur radio antenna. Complete details in text.*

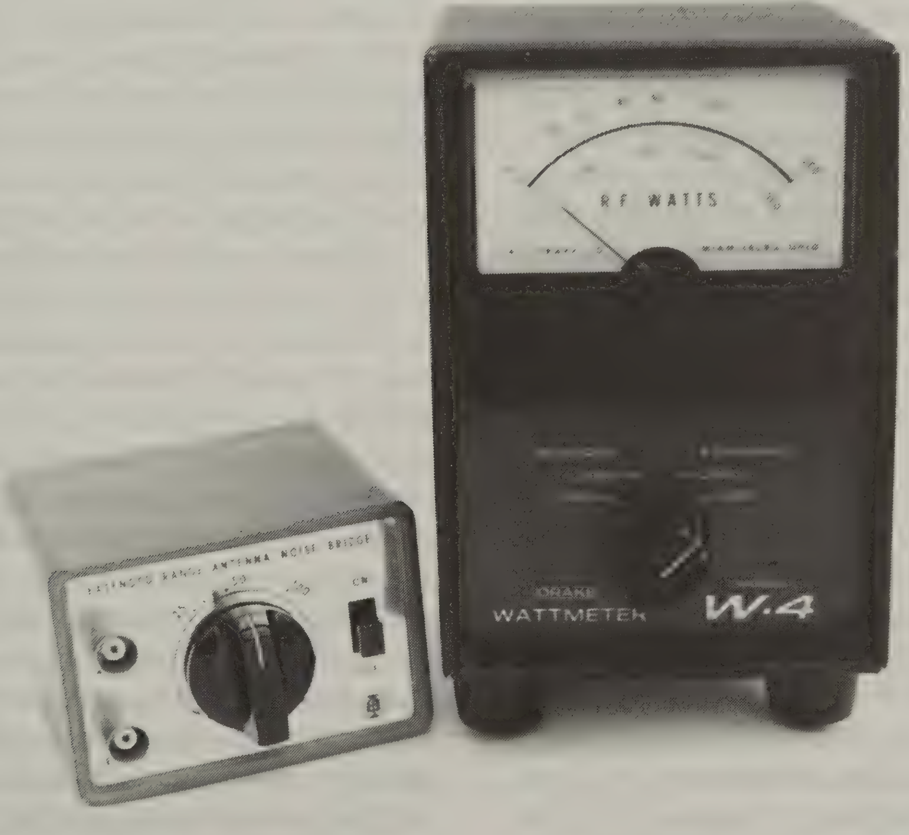


Figure 1-5 *Two of the most useful and handy accessories any radio amateur can possess are a forward/reflected power meter or SWR bridge and its "silent partner," an antenna impedance noise bridge.*

inductive/capacitive reactance scales. The reactance scale tells if an antenna is "too long" (X_L) or "too short" (X_C) for a particular frequency. Noise bridges are also useful for pretuning transmatches (dial the receiver to the desired frequency, set the impedance dial to 50 ohms, adjust the tuner for minimum noise, then connect the transmitter). Noise bridges can also be used for electrically measuring coaxial cable phasing lines, pretuning linear amplifier tank circuits, and much more. The unit is a modern replacement for previously popular grid dip meters.

SUCCESS TIPS FOR FIRST-TIME INSTALLATIONS

The following information is presented primarily for newcomers to amateur radio; however, several of the ideas also can prove enlightening for veteran radio amateurs. We are all searching for the perfect sky wire, and every piece of information acquired during that pursuit is beneficial. If you pick up only one tip or thought-inspiring note by reading this, it is worth the effort.

When planning your first antenna installation, try to select a horizontal type that does not use phasing sections or an end feed. Dipoles, Inverted Vees, and single band Delta Loops are always good choices. They are easy to assemble and erect, there is little chance of failure, they do not require using a tuner, and they are a good reference for comparing future antennas. You can consider an antenna that does not "get out" a signal as effectively as a dipole as "compromising," and an antenna that works better than a dipole as quite desirable. If you are familiar with antenna tuner operations, a G5RV or Carolina Windom can be added in "first choice" categories. Both of these sky wires exhibit better gain than a dipole on the upper HF bands. The automatic antenna tuner included in styles of several deluxe transceivers (e.g., Kenwood's TS-940 and ICOM's IC-761) work well with the G5RV and Carolina Windom. They are "unbalanced output" tuners, however, and do not operate properly with "balanced" antennas such as the classic all-band doublet or extended double Zepp.

Vertical antennas are always appealing because they seemingly require minimum mounting space and can be installed right at ground level. Factually however, verticals need a unobstructed area and a good ground system to properly radiate a signal. Many amateurs have unnecessarily and prematurely become discouraged with verticals (but not with amateur radio overall, we hope) because they did not seriously consider the two previous factors. A vertical mounted between hills, amidst a grove of trees, within 20 feet of a building, or supported by a single ground stake simply cannot radiate an effective signal. It is choked and RF blocked, and half of its energy is absorbed by the ground. Verticals perform well when they are installed atop a hill, are unobstructed in all directions, and use a series of ½-wavelength radials to recreate their "missing half." These are rather difficult prerequisites for newcomers to properly fulfill, so begin with a horizontal wire and add a vertical radiator after enjoying on-the-air success and learning to recognize good, poor, or better antenna performances.

Safety and considerate protection of property are always important in any antenna installation. If you cannot launch a tow line over a desired top tree limb without endangering yourself or a neighbor's window, be content with a lower height sky wire. There is also consolation in knowing your antenna is not the highest structure in the neighborhood when thunderstorms begin rumbling. Clear sky views are also very important. Try to "string" your antennas between trees rather than through them. Many amateurs prefer erecting wire antennas between a house and garage rather than between tall trees. They radiate very well although their antennas are lower than the "tree-supported" equivalents. Interesting, eh?

As a general rule of thumb for first horizontal wire antennas, consider 20 to 25 feet as a good minimum center height above ground and over 70 feet as questionable in regard to safety. Try to install the antenna close enough to your station so not more than 80 feet of coaxial cable is required for hookup. Avoid erecting the antenna directly over your station to minimize RF feedback. These notes indicate a dipole with its center connections roughly 35 feet above ground, parallel to your equipment and 20 to 40 feet away will be successful. That is not saying 100 other different installations will not work equally well, it is simply guidance from an old-timer (the author) who has installed and used numerous antennas during the last 25 years (I started in ham radio at a young age. Honest!). Additional guidance on antenna installation and station interconnection are shown in **Figure 1-6**. You can follow that outline for your first antenna and rest assured its success will outweigh its problems.

When routing coaxial cable into the house, be careful to avoid sharp bends or pinches. Coaxial cable has a short life (7 to 14 years) under good conditions. Do not lower it by damaging the cable's dielectric or center conductor. As discussed elsewhere in this book, removing strain and raising the coaxial cable above acidic ground also ensures a longer cable life.

After installation, if you end up with extra coaxial cable from your antenna in your "shack," cut it off rather than coiling it up or weaving it around baseboards. Remember, long cables usurp precious watts. An exception to that rule is an antenna cable less than 15 or 20 feet (maybe your rig is in an attic and your antenna is 10 feet from an adjacent window). In such cases, let the coaxial cable droop toward the ground and make a wide loop before raising it back up to the attic window. Coaxial cables less than 20 feet often produce high, hard-to-correct SWRs.

Standing Wave Ratios above 2:1 cause modern solid state transceivers to reduce their RF output for self-protection. The best way to correct a high SWR involves shortening an antenna's length to raise its resonant frequency or extending its length to lower its resonant frequency. After that step, prune the coaxial cable's length in one foot steps until a low SWR is measured at the station's transceiver. Modern rigs love that "thoughtfulness."

The most important point is putting up an antenna (even if it is a compromise) and getting on the air. You worked for your license, the hard part is behind you, and an exciting world of enjoyment is in front of you. Regardless of the rig or antenna, enjoy amateur radio. It is a life-long hobby with a thousand fascinating areas of pursuit. Go for it!

ANTENNAS, NEIGHBORS, AND PUBLIC RELATIONS

One of the typical oversights of many radio amateurs heavily involved or pressed for time is neglecting to establish a favorable rapport with the neighborhood. This is easy to do in today's busy society, but the repercussions can really "strike home" when one puts up a large and visible antenna. Wire antennas are not the "attention getters" of towers and beams, true, but maintaining a good image in light of future times and dreams (or merely staying on the air when zoning laws become even more unfair) has untold benefits. How does one accomplish this? Begin your antenna farm "low key." Erect an inconspicuous dipole or long wire, get to know your neighbors, and start saving for that massive dream array. Help two or three neighbors with a simple chore or two and your "public image" will flourish. Taking a few minutes talking or working with area youngsters can also bring returns in several ways. They can learn from you—maybe become hams—they know who might oppose antennas and who will not, who watches television constantly, and who might even like to help on installation day. Youngsters also pass encouraging words around

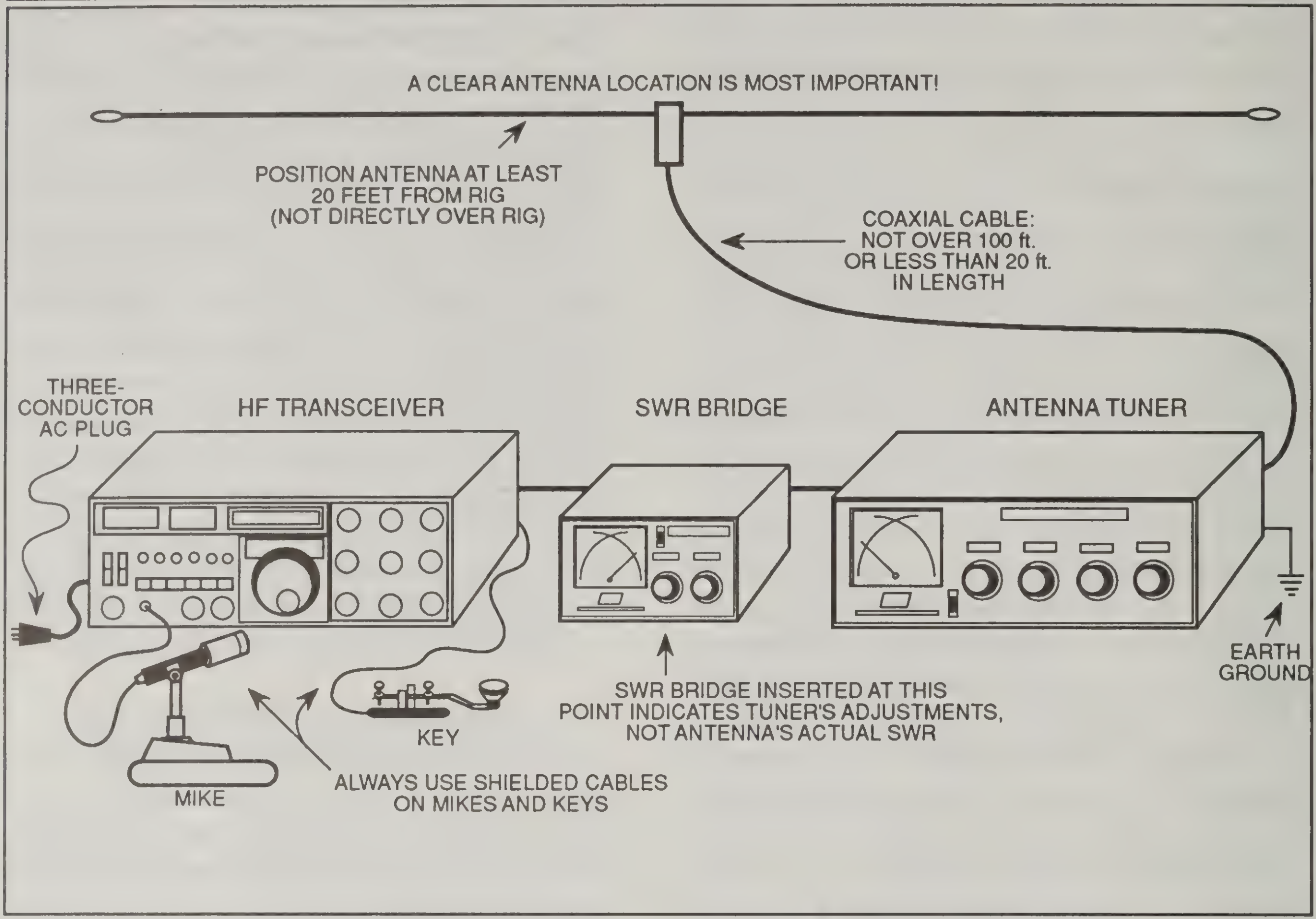

A CLEAR ANTENNA LOCATION IS MOST IMPORTANT!
POSITION ANTENNA AT LEAST 20 FEET FROM RIG (NOT DIRECTLY OVER RIG)
COAXIAL CABLE: NOT OVER 100 ft. OR LESS THAN 20 ft. IN LENGTH
THREE-CONDUCTOR AC PLUG
HF TRANSCEIVER
SWR BRIDGE
ANTENNA TUNER
EARTH GROUND
SWR BRIDGE INSERTED AT THIS POINT INDICATES TUNER'S ADJUSTMENTS, NOT ANTENNA'S ACTUAL SWR
KEY
MIKE
ALWAYS USE SHIELDED CABLES ON MIKES AND KEYS

Figure 1-6 *Success tips for first-time antennas and stations. Discussion in text.*

neighborhoods. If you become a neighborhood "good guy," you will be able to erect almost any kind of antenna desired and be appreciated for doing it. The old "give and take" theory still has merit.

Generally speaking, wire antennas are unobtrusive in nature and well suited for critical visibility installations. This should not initially be construed as an ideal "secret radiator" solution for condominiums or apartments until other avenues of public relations have been given a logical chance for success. Before dipping wires and feed lines in green and blue camouflaging paints, do some private investigating into neighborhood opinions and ideas. You might be able to use trees on adjacent property for supports while nullifying radiation toward the apartment complex's master television antenna. Think cleverly and use your ingenuity in every installation situation.

ANTENNA NOTES

CHAPTER TWO

UNDERSTANDING TRANSMISSION LINES

INTRODUCTION

During the early days of radio, RF energy was carried from a station's transmitter to its antenna via open-air wires or feeders. Although those electromagnetic lifelines were quite effective and lost little energy, their physical placement and proximity to nearby objects often created transmission difficulties. During that same era, a special concentric conductor, coaxial cable, was developed for intercontinental "wired" communications. As various forms of coaxial cable became available commercially, radio amateurs accepted its use as an "easy to work with-put it anywhere" transmission line medium. While open-air feeders are still effective forms of transmission lines, today's radio amateurs unanimously prefer the many styles of coaxial cables (e.g., polyethylene or vinyl jackets with copper braid shielding).

As we all know, a transmission line's main purpose is conveying RF energy between a transmitter/receiver and its antenna. If that purpose is successfully accomplished, theoretically all of a transmitter's available output will be conducted through the line and radiated only by the antenna. As reality affects us, however, few antennas accept and radiate all of their applied power. External influences are always present and affect each setup differently.

Radio waves travel through a transmission line, then "spread out" on the antenna itself. Additional oncoming energy propels the waves into space as electromagnetic energy moving at the speed of light. While most antennas may be theoretically matched to their transmission line (50-ohm antenna and 50-ohm coax), "outside influences" such as the height above ground, the ground's conductivity, nearby trees and objects (including the antenna's own feed line), add capacitive or inductive reactance which alter actual feed-point impedance. The combination of forward and reflected energies then creates a resultant third energy wave which does not move but "stands" on the transmission line. The size (amplitude) of this standing wave depends on antenna/transmission line mismatch and can be measured with an SWR bridge or forward and reflected power meter. **See Figure 2-1.**

What are the effects of high SWRs (above 2:1) and to what extent are they detrimental to a station's overall performance? That has been one of the most discussed and debated areas in amateur radio for several decades—and an area we will leave open to your personal opinion, investigation, and evaluation. On one hand, some experts believe that SWRs of 2:1 or higher cause substantial losses of otherwise usable RF power. In fact, the U. S. Navy has several training films showing how high SWRs actually burned holes in coaxial transmission lines. On the other hand, other experts feel that high SWRs cause negligible signal attenuation and can be accepted if feed-point impedance is within the utilized transmitter's range. There are documented theories suggesting reflected energy returns to the antenna to produce

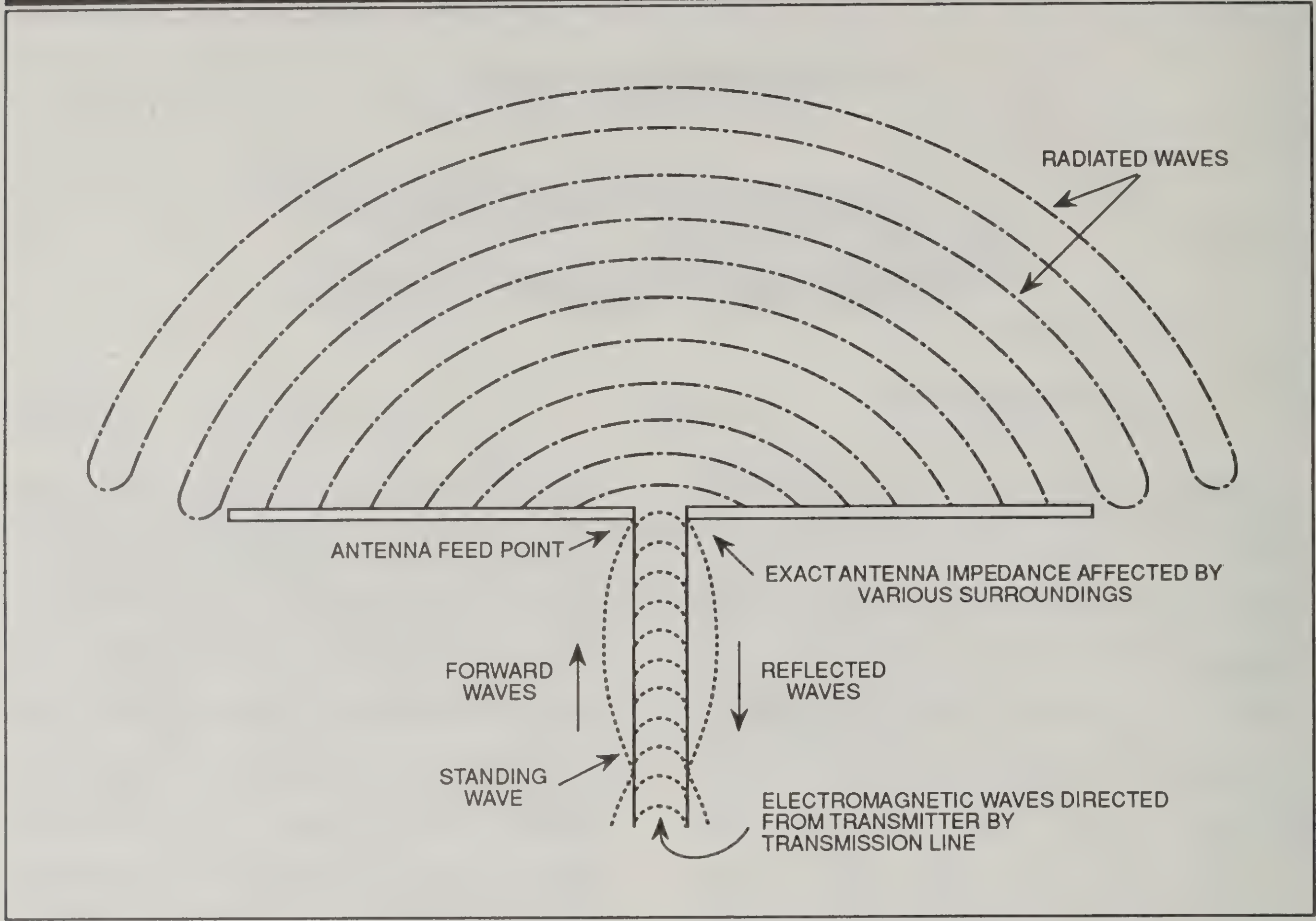

RADIATED WAVES
ANTENNA FEED POINT
EXACT ANTENNA IMPEDANCE AFFECTED BY VARIOUS SURROUNDINGS
FORWARD WAVES
REFLECTED WAVES
STANDING WAVE
ELECTROMAGNETIC WAVES DIRECTED FROM TRANSMITTER BY TRANSMISSION LINE

Figure 2-1 *Basic concept of how electromagnetic waves are conveyed down a transmission line and radiated into free space by an antenna.*

reflected gain, and SWR meter readings are significantly influenced by outer currents on coax cables.

In summary, we merely suggest always striving for an acceptably low SWR and a feed-point impedance within the range of the transmitter used in your antenna system. The station's transceiver will reward you with long-lasting performance, and your antenna's radiation will be close to expectations. SWRs between 1.5:1 and 2:1 are rough on solid state final amplifiers. SWRs above 2:1 usually indicate antenna troubles especially if that change is rather sudden (keep written records from the first day of installation). SWRs above 2:1 also usually indicate both antenna and feed line are radiating (will the real antenna please stand up . . .).

TYPES OF COAXIAL TRANSMISSION LINES

Coaxial cables are available in a wide variety of sizes and characteristics to suit any radio amateur's needs. Generally speaking, cable efficiency is directly related to size. Larger diameter cables have less overall energy loss and are capable of handling higher RF power levels. Three other factors relative to all coaxial cables are: the outer jacket quality, dielectric material type, and the amount of copper braid shielding. Older and/or less expensive coax is usually enclosed in a poor plastic outer jacket. After a few months of weathering, its inner layer begins to contaminate interior conductors and renders the cable prone to power loss and almost worthless. Newer high-quality cable is covered by a non-contaminating outer jacket. All jackets are black, so check the cable's specifications before purchasing it. Inner dielectric is another consideration; low loss or "foam" types are especially suited for obtaining the use of every available watt of power. Finally, top-quality cable will feature a tightly woven shield or braid around its inner dielectric (98 percent coverage), but visible openings (slits) can be detected on poor cables. Cut a sample of the coax you plan to use, dissect it and check its quality. Note the previous parameters and purchase accordingly. When in doubt, select the most expensive cable you can afford (RG213/u, for example). Always select high-quality cable and avoid "bargain" or used cable. You will be rewarded with continuing excellent operation, and you will not need to worry excessively when snow or blistering sun begins working its mischief. Coaxial cable has a varying life span of seven to fourteen years. A general description of some popular coaxial cables follow, and a summarization is included in **Figure 2-2.**

RG58/u: A popular small diameter 52 ohm cable suitable for HF applications of "short runs" (less than 100 feet), and not over 700 watts of power. Typical attenuation: 1.4 db per 100 feet.

RG59/u: A 75 ohm version of RG58/u cable, except slightly larger in diameter. Handles up to 1000 watts. 1.1 db attenuation typical per 100 feet.

RG174/u: Super-small 52 ohm cable primarily for HF "runs" not exceeding 50 feet. Diameter: ¼ inch. Typical attenuation: 4 db per 100 feet. Power handling ability: 170 watts maximum.

RG8/u: The "amateur's standard" 50 ohm cable. Can be used for HF or VHF. Approximately ½ inch diameter. Handles up to 3700 watts. Attenuation typically 0.6 db per 100 feet.

RG213/u: A top quality and low loss version of RG8/u that is ideal for HF or UHF applications. Approximately ⅝ inch diameter. Handles up to 5000 watts. Attenuation typically 0.4 db per 100 feet. Shielding and outer jacket construction quality are superb.

Additional and improved cables are being introduced to industry every few months. Check your local sources for information and compare new specs with previous "old standbys."

WORKING WITH TRANSMISSION LINES

In order to realize maximum long-term results with any antenna system, particular care must be given to installing and weatherproofing its transmission line. Overlooking this consideration usually results in an antenna system that initially works great, then its performance begins to deteriorate. A classic example here is a doublet connected to coaxial cable by its "pigtailed" shield and center conductor leads which are protected only by tape. Moisture quickly enters the cable and spreads along its full length by capillary action. Within a few months, the waterlogged cable effectively becomes an outdoor attenuator. Never damage a cable's outer jacket, protect exposed ends as if they were going to be used under water, avoid any sharp bends, and you will enjoy long-lasting performance.

Because antennas are often placed at difficult-to-reach locations, you might consider running some brief cable checks before the arrival of "installation day." This consideration holds special merit if you are using unfamiliar cable or (heaven forbid!) reusing a length of "aged" cable. First, check overall conductor continuity while insuring low DC resistance. Next, check the center conductor to braid for infinite resistance. As an operational check, connect the cable between the

CABLE TYPE	IMPEDANCE (OHMS)	MAXIMUM RECOMMENDED POWER (WATTS)*	VELOCITY FACTOR (%)	PFD PER FOOT (PFD)	ESTIMATED ATTENUATION PER 100 FEET*
RG 174A (mini coax)	52	180	66	38	3.89 db
RG 58A	52	600	66	28	1.6 db
RG 58A Foam	52	700	79	26	1.4 db
RG 8A	52	2500	66	30	0.7 db
RG 8A Foam	52	3500	81	26	0.6 db
RG 213/u	52	5000	80	26	0.4 db
RG 59A	72	1200	66	20	1.1 db
RG 59A Foam	72	1000	79	17	1.0 db
RG 11A	72	2000	66	21	0.7 db
RG 11A Foam	72	3000	80	17	0.5 db
OPEN WIRE 1" Spacing	300	2000	96	-	Negligible
OPEN WIRE	450	2500	-	-	Negligible

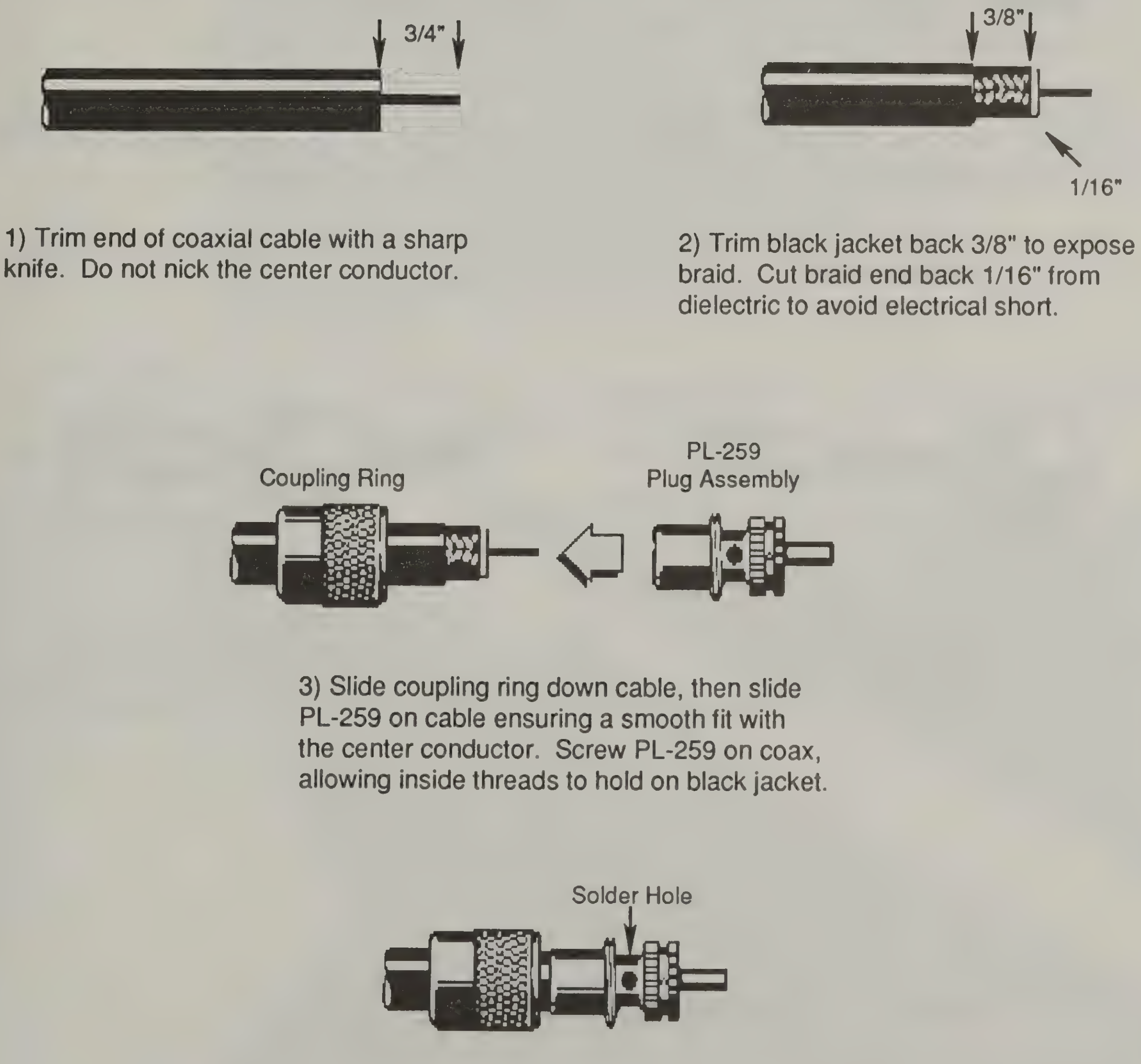
** NOTE: ASSUMES NEW CABLE AND 14 MHZ USE.*

Figure 2-2 *Basic characteristics of popular coaxial cables/feedlines used by radio amateurs.*

station's transmitter and dummy load and measure RF power at the dummy load. Finally, remove the cable, place the dummy load at the transmitter's output, measure RF power, and compare figures.

When installing RF connectors on coaxial cables, remember the importance of that "in the sky" connection. Use sufficient heat and solder, but do not overindulge on either. Polish the center plug with a few knife scrapings, then tighten it securely to its mating jack. **See Figure 2-3.** If plugs and jacks are not used (such as a dipole without a center balun), use an enclosed center insulator to protect exposed solder connections and cable ends. Finally and most importantly, protect the complete RF junction, from the radiator(s) feed point to a few inches downward on the feed line, with a liberal wrapping of hand-moldable Coax Seal®. This product is an absolute necessity for long-life outdoor connections. **See Figures 2-4 and 2-5.**

LARGE COAXIAL CONNECTORS



1) Trim end of coaxial cable with a sharp knife. Do not nick the center conductor.

2) Trim black jacket back 3/8" to expose braid. Cut braid end back 1/16" from dielectric to avoid electrical short.

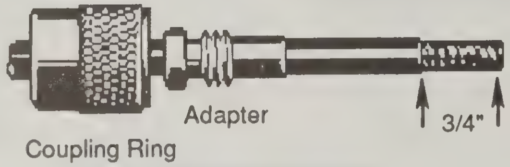
3) Slide coupling ring down cable, then slide PL-259 on cable ensuring a smooth fit with the center conductor. Screw PL-259 on coax, allowing inside threads to hold on black jacket.

4) Solder coax center conductor to PL-259 middle pin, then solder shield through holes in PL-259. A 250 watt soldering iron is suggested. Complete by sliding coupling ring onto body of PL-259.

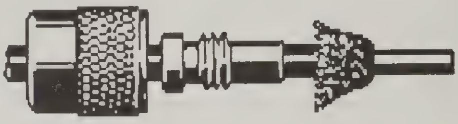
Figure 2-3A *Installing PL-259 connectors on coaxial cables. Remember to double check your finished work with an ohmmeter before installing it in that hard-to-reach outdoor location.*

SMALL COAXIAL CONNECTORS

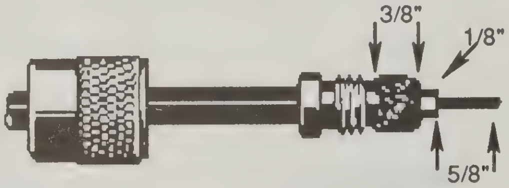
Note: UG 175/u = RG58u
UG 176/u = RG59u
cable reducers



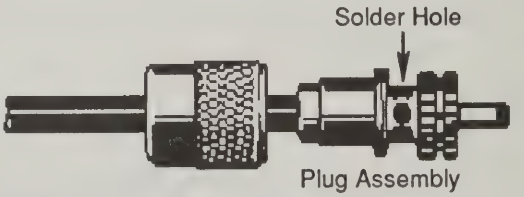
1) Cut end of cable even. Remove vinyl jacket 3/4"- don't nick braid. Slide coupling ring and UG reducer on cable.



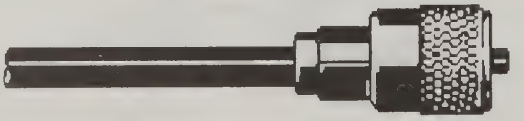
2) Fan braid slightly and fold shield back and trim at 3/4". Trim dielectric to expose 5/8" of center conductor.



3) Leaving 1/8" gap of dielectric area, position UG adapter as shown. Press braid down over body of adapter and trim to 3/8". Tin exposed center conductor.



4) Insert plug assembly into PL-259, watching center conductor alignment. Solder coaxial center conductor to PL-259 middle pin, then solder shield through holes in PL-259.



5) Screw coupling ring on plug assembly.

Figure 2-3B *Installing PL-259 connectors on coaxial cables. Remember to double check your finished work with an ohmmeter before installing it in that hard-to-reach outdoor location.*

NEW
HAND MOLDABLE PLASTIC
COAX-SEAL
SEALS COAX FITTINGS FROM MOISTURE AND CORROSION
Stays Flexible At Any Temperature
Permanent-Long COAX Life
...Provides Years of Protection
Insures Low SWR
Forms and Seals Over Odd Shaped and Difficult COAX Fittings
Fast-Easy Seal for All Antenna Connections
Non-Contaminating
Non-Conductive

Figure 2-4 *A vitally important item for weather -protecting any and all outdoor antenna connections is "CoaxSeal" (a hand-moldable plastic material distributed by Universal Electronics of Columbus, Ohio).*

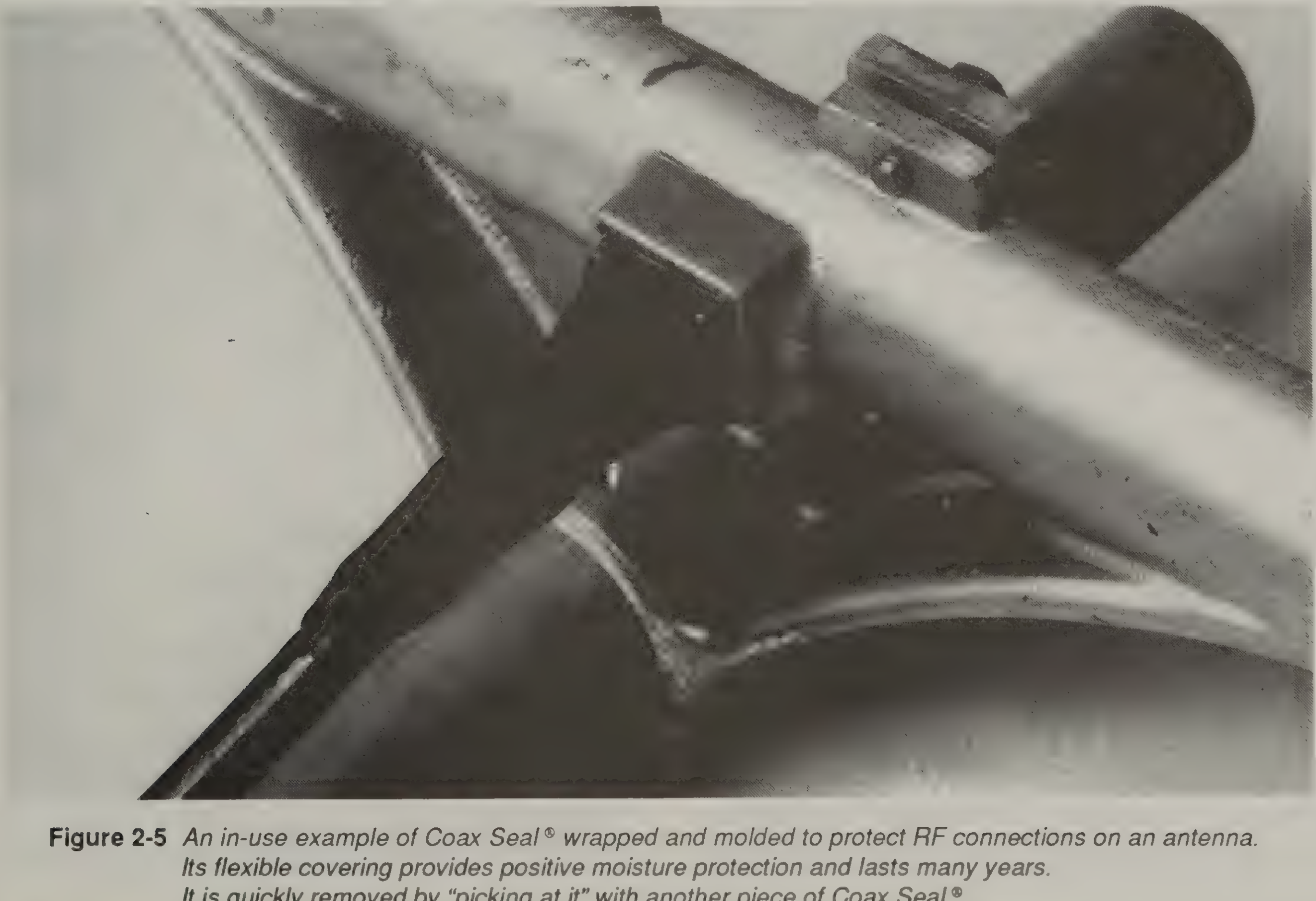


Figure 2-5 *An in-use example of Coax Seal® wrapped and molded to protect RF connections on an antenna. Its flexible covering provides positive moisture protection and lasts many years. It is quickly removed by "picking at it" with another piece of Coax Seal®.*

ANTENNA NOTES

CHAPTER THREE

STRAIGHT FACTS ON WIRE ANTENNAS

INTRODUCTION

Wire antennas traditionally have been popular items among radio amateurs because of their low cost, efficiency, and relative ease of assembly. These radiators are logical media for operating long wavelength bands between 160 and 40 meters; however, they also perform beautifully on "upper bands" including 2 meters and 70 centimeters. There may be a few "mysteries" in the world of antennas and signal propagation, but rest assured the same kind of DX communicating electromagnetic waves emanate from both wire and aluminum tubing radiators. As a means of increasing your knowledge and self-confidence in this area, let us take a closer look at some factors applicable to all antennas in general and wire antennas in particular.

The theoretical radiation pattern for any antenna is indeed theoretical, and real-life situations vary somewhat with each installation. In-field objects (including supports, roof edges, ground composition, etc.) warp or absorb various portions of energies, sometimes across a full amateur band and sometimes on a particular band end. Directional antennas with traps or loading coils are quite prone to this phenomena: front-to-back ratios and forward gain (plus feed-line radiations) change noticeably between phone and CW segments of a band. Also, most handbooks or manuals illustrate only "top views" of radiation patterns. Consider an antenna's radiating elements as long neon lights and you will be able to visualize energy emanating around the tube's full circumference (two such "butted neons" would be analogous to a dipole; placing a reflector behind and a projection lens in front of the neon tubes would simulate a Yagi beam. A matte black cloth or polished mirror below it would imitate the ground). Whatever type of antenna is being considered, try to visualize its hypothetical pattern from both horizontal and vertical angles (or top and side) for maximum clarity. This concept is illustrated in **Figure 3-1.** Notice the pattern's side view. The lobes are canted upward and may be unequally absorbed or attenuated according to ground effects. Because we cannot physically view this radiation, we are usually limited to simply estimating its true form through simple element sightings and basic field intensity measurements.

Many radio amateurs have expressed mild uncertainty about the seldom-explained material we call antenna wire. Does it have any special radiation properties, is it insulated or bare, large or small, solid or stranded? Yes, yes! Almost every kind of wire imaginable has been used as "official antenna wire" and all of it worked beautifully. Various forms of bare copper-coated wire are the most popular materials, with aluminum wire used when little else is available. Insulated hookup wire is good antenna material for low to medium power setups, and it can be dipped in green and grey camouflaging paint for "low key" installations (When 30-meter operation was first authorized, we quickly strung a dipole of orange insulated hookup wire and

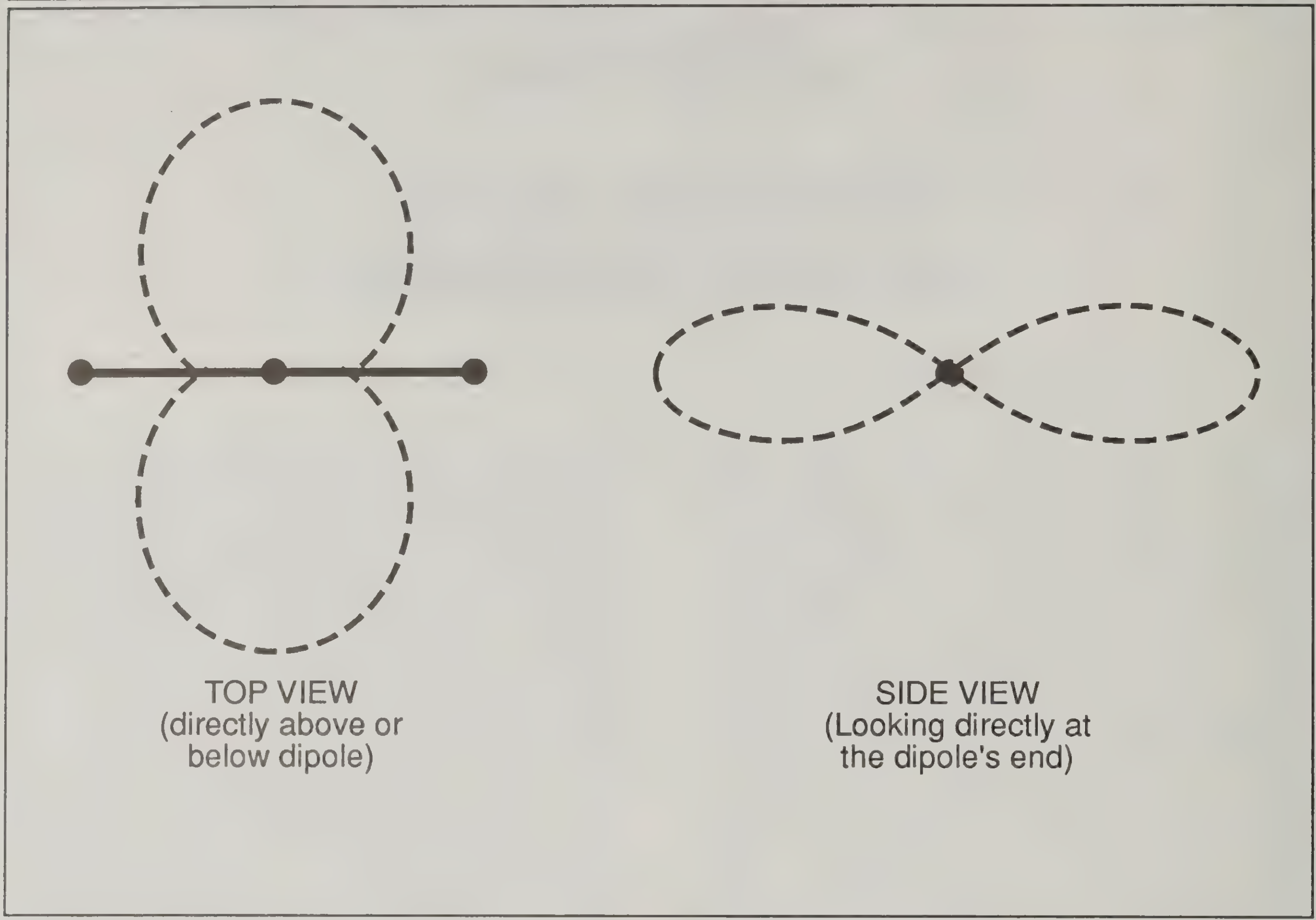

TOP VIEW
(directly above or below dipole)
SIDE VIEW
(Looking directly at the dipole's end)

Figure 3-1 *Hypothetical radiation pattern for a horizontal dipole illustrating both top and side views. Due to in-field objects influencing antenna radiation, the actual pattern is not always symmetrical. See text.*

clothespin insulators. They worked so well at the 100-watt level that replacing them with bare copper wire and fancy insulators was unjustified!). RF energy will pass through insulation without attenuation. It is also noteworthy that stranded wire has the ability to withstand a reasonable amount of outdoor bending and twisting without breaking, whereas solid wire occasionally "snaps." Probably the most common antenna wire is stranded copper from number 12 to 16 gauge (it turns black after a few month's use but lasts for several years). Another popular wire is "copperweld" (a solid wire with a springy steel center that can almost pull two trees together or inflict nasty scratches when it abruptly jumps out of your hand). Wire gauges between number 12 and 16 are suggested for power levels up to 500 watts, and number 6 to 12 gauge is suggested for power levels up to 1500 watts. **See Figure 3-2.**

A COMMON GUIDE TO THIS BOOK'S ANTENNAS (AND OTHER ANTENNAS)

Have you ever been discouraged from constructing an antenna found in a magazine or radio handbook because its presented dimensions were not related to your favorite band of operation? That problem arises more times than anyone cares to admit, but it need not become a serious obstacle for any radio amateur with a calculator. That's right, a little formula juggling and substitution of variables can adapt almost any antenna's measurements to your own preferred frequencies.

Antenna formulas are interesting in the respect that any two known variables can be used to find an unknown third variable. This is done by rearranging the parameters into a "circle formula" and substituting a "times" sign (X or ⋆) for the "equals" mark. The formula

$$F\ (\text{mHz}) = \frac{234}{1/4\lambda\ (\text{feet})}$$

for example, is rewritten in **Figure 3-3** as

$$\frac{234}{F\ (\text{mHz}) \times 1/4\lambda\ (\text{feet})}$$

As an example of its use, let us "plug in" some figures we all recognize. 234 ÷ 14.0 mHz = 16.714 feet (used for finding the length of ¼-wave antenna). Also, 234 ÷ 16.714 feet = 14.0 mHz (useful for finding the resonant frequency of "five percent longer" reflectors or "four percent shorter" directors, velocity factor-cut transmission lines, etc.). Likewise, 14.0 mHz ⋆ 16.714 feet = 233.996 (useful for determining a "common parameter" for scaling various antenna dimensions found in books and magazines to other frequencies). Let us assume you are planning to construct a previously popular "ZL Special" array for our new 30-meter band and need to convert its dimensions accordingly. **See Figure 3-4.** F(14.100) ⋆ L(31.5 feet) = Common Parameter (444.15). Recalculating for 30 meters gives: 444.15 ÷ F(10.120) = 43.88 feet overall length of radiators. Likewise, F(14.100) ⋆ L (8.7 feet) = Common Parameter (122.67).

Figure 3-2 *Some of the basic ingredients for assembling and erecting this book's star performers: wire antennas of various shapes, sizes, and design possibilities.*

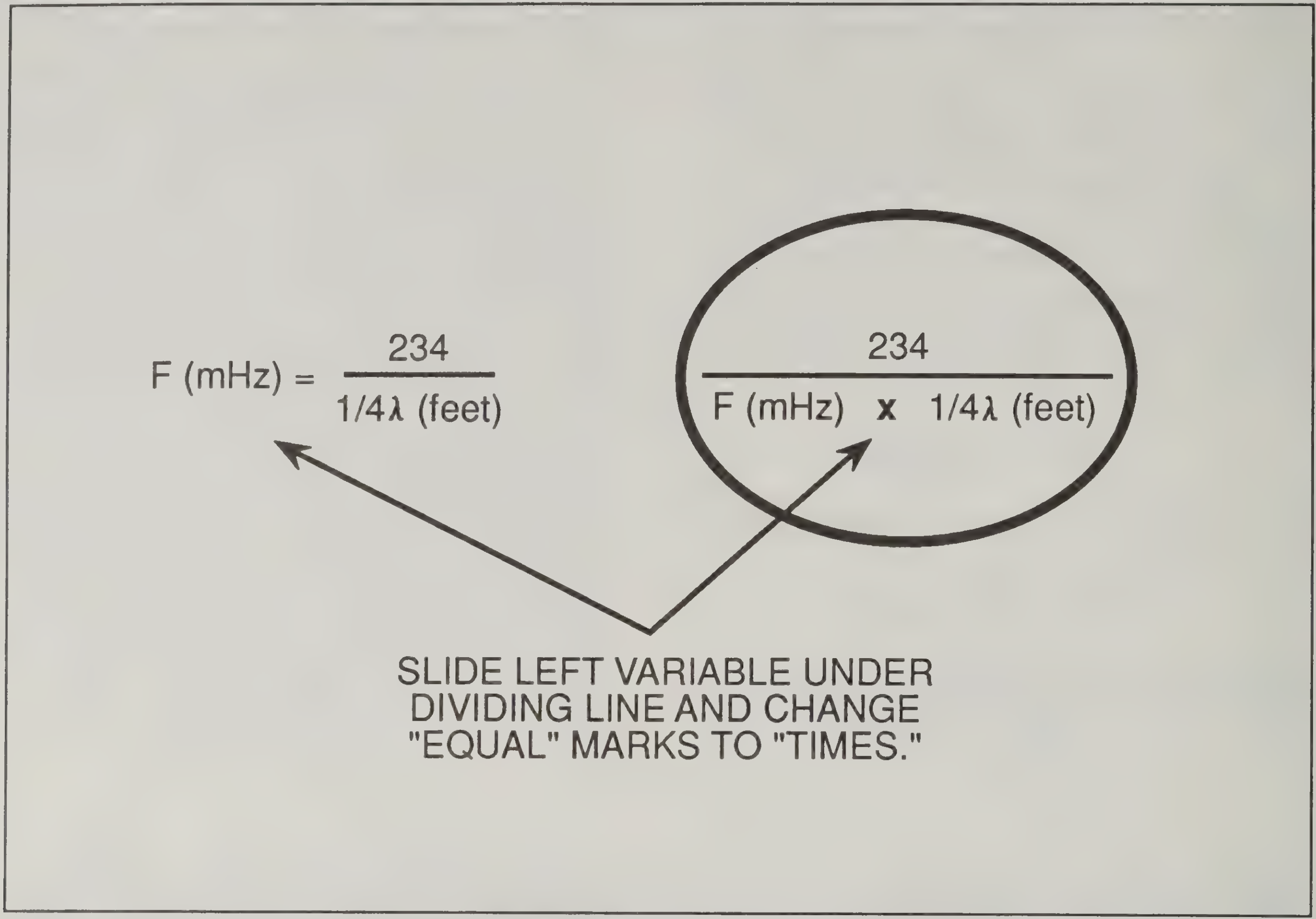

F (mHz) = 234 / 1/4λ (feet)
234 / F (mHz) x 1/4λ (feet)
SLIDE LEFT VARIABLE UNDER DIVIDING LINE AND CHANGE "EQUAL" MARKS TO "TIMES."

Figure 3-3 *An easy method of converting electronic formulas to "find any variable" circle formula. Block out the sought parameter, then follow indicated mathematical operations.*

Recalculating that phasing section for 30 meters gives: 122.67 ÷ F(10.120) = 12.12 feet. Antenna scaling isn't difficult. Incidentally, if you build this particular antenna, use either a 50 to 72 balun transformer at the feed point or connect to your setup with 72-ohm twin lead and a balanced output transmatch.

Now let us assume you are planning a "traveler's special" wire Yagi antenna for 12 meters and try some more dimensioning ideas. 468 ÷ F(24.930 mHz) = 18.77 feet overall half wavelength of driven element (a quick check: is this size between that of 10- and 15-meter Yagis?). The five percent longer reflector will be: 0.05 * 18.77 feet = 0.938 or 19.71 feet total. If you use a noise bridge and receiver for checking and setting resonance (the point of minimum receiver noise with bridge), the reflector's frequency should be 468 ÷ 19.71 feet, or 23.744 mHz. The last calculation is especially useful when constructing mini beams with helically wound elements or middle loading coils.

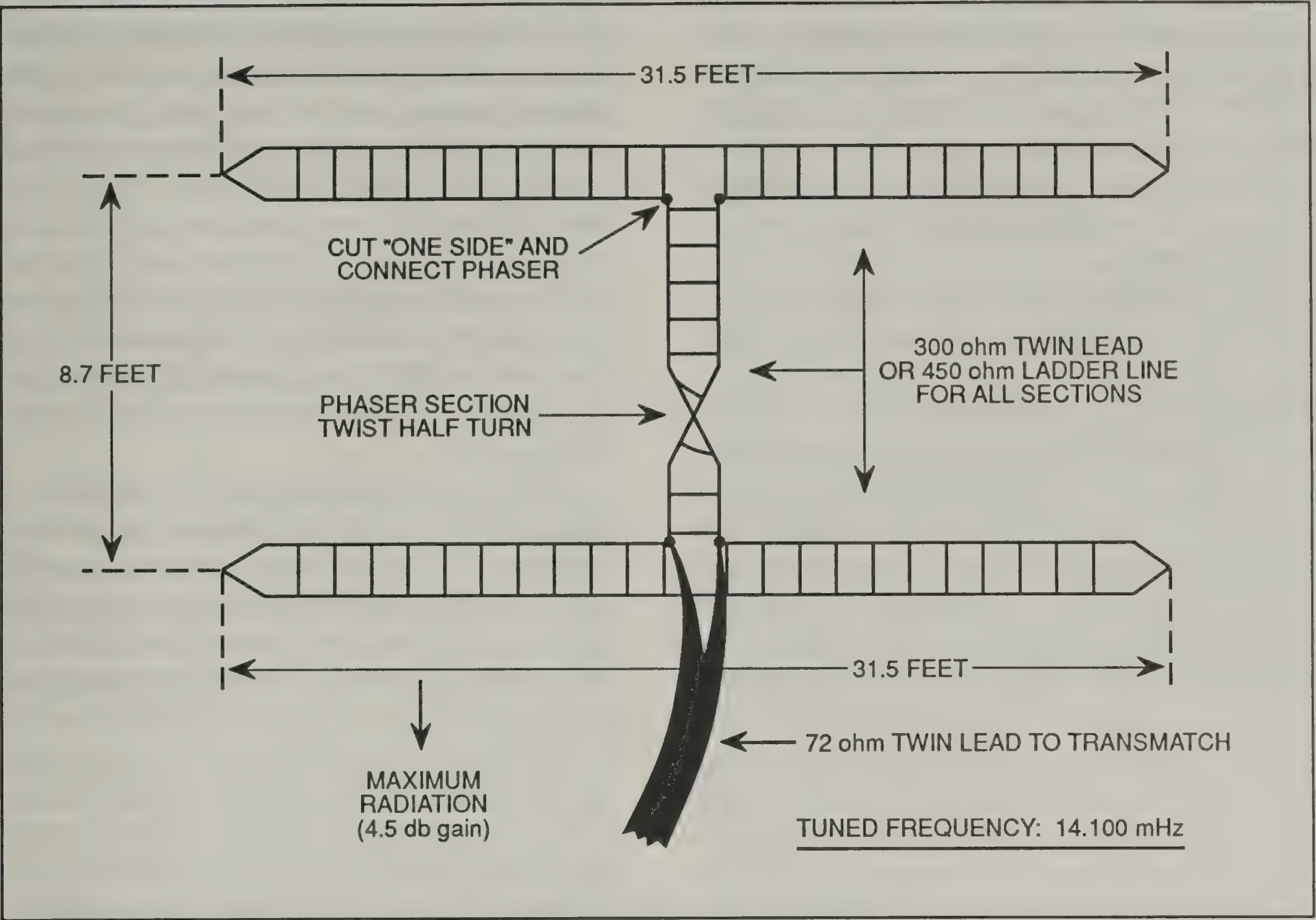

31.5 FEET
CUT "ONE SIDE" AND CONNECT PHASER
8.7 FEET
300 ohm TWIN LEAD OR 450 ohm LADDER LINE FOR ALL SECTIONS
PHASER SECTION TWIST HALF TURN
31.5 FEET
72 ohm TWIN LEAD TO TRANSMATCH
MAXIMUM RADIATION (4.5 db gain)
TUNED FREQUENCY: 14.100 mHz

Figure 3-4 *The popular ZL special antenna as originally dimensioned for 20 meters. The text explains a simple means of converting measurements shown to any other band or frequency desired.*

BALUNS AND TOROIDS

Two items of special interest to any antenna enthusiast are balun transformers and toroidal cores. Both these items are useful for manipulating RF related factors, and each has its own area of application in signal radiations. When a center fed antenna such as a dipole beam's driven element is directly connected to a station's coaxial cable, one element is connected to the line's center conductor while the "other side" is connected to the shield (which is also connected to the station's ground). This unbalanced line (one conductor being grounded) to balanced line (one conductor being grounded) to balanced antenna (both sides are "above" ground) situation can noticeably distort an antenna's radiation pattern. Likewise, currents flowing over the outer shield can also cause the coaxial line to act like a vertical radiator and further alter the antenna's directivity pattern (the horizontal antenna then begins to radiate like a directive top hat). Assuming the antenna does not have design defects, these radiation consequences can be minimized by installing a compact balun at the antenna's coaxial feed point (a number of these baluns are available commercially). **See Figure 3-5.** As a benefit of balancing an antenna's radiation capabilities and reducing its feed-line radiation/pickup, both transmitted and received signals can be noticeably improved. The term "balun" is an acronym for "BALanced to UNbalanced" transformer. The item also can be used either way, balanced to unbalanced or unbalanced to balanced. Baluns especially designed for amateur radio use are readily available in both 1:1 and 4:1 impedance transformations. These items can also be homemade using various forms of coaxial cables.

Toroidal cores are useful for "choking" RF energy in several ways. A transmission line may be looped through a large toroid several times to reduce feed-line radiation (typical core diameter is three inches). A transceiver's AC cord can be passed through a toroidal core three or four times to effectively "break up" RF energy paths to other household electronic devices. A television's antenna lead-in (300-ohm twin lead or 75-ohm coaxial cable) can be wrapped around a three or four inch toroid several times to create a TVI filter. If the set's AC cord and antenna lead-in are wound in opposite directions and on opposite sides, that single core can serve double duty in choking HF-related RF energy. The diameter of a toroidal core is an obvious clue to its frequency range of effectiveness. That is, larger cores (three to four inches) choke low frequencies (HF range) while passing higher frequencies (VHF, etc.), and small cores usually choke only upper frequencies (VHF, UHF, microwaves).

Useful and often overlooked sources of large toroidal cores are picture tube deflection yoke centers on discarded or junked TV sets. A brief trip to a local TV shop or area dump usually produces one or two salvageable yokes. Carefully unwind the deflection

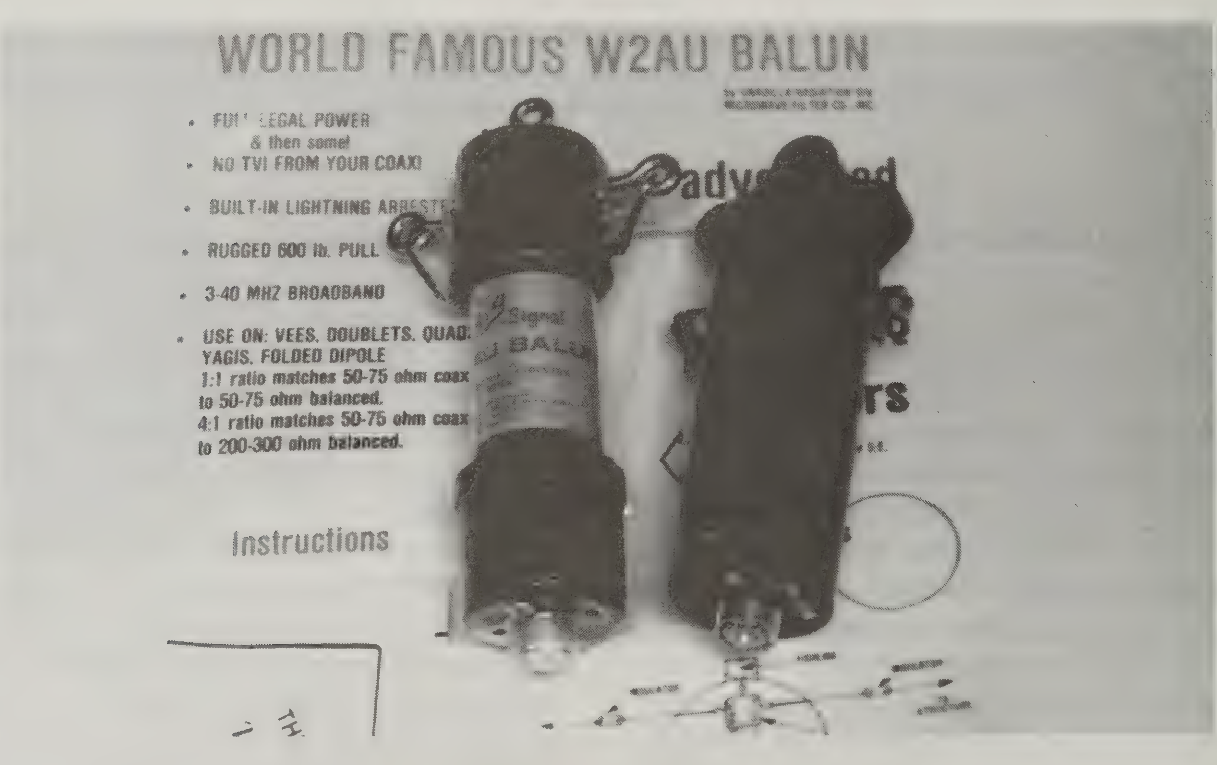

WORLD FAMOUS W2AU BALUN
• FULL LEGAL POWER & then some!
• NO TVI FROM YOUR COAX!
• BUILT-IN LIGHTNING ARRESTE
• RUGGED 600 lb. PULL
• 3-40 MHZ BROADBAND
• USE ON: VEES, DOUBLETS, QUAD, YAGIS, FOLDED DIPOLE
1:1 ratio matches 50-75 ohm coax to 50-75 ohm balanced.
4:1 ratio matches 50-75 ohm coax to 200-300 ohm balanced.
Instructions
BALU
TS

Figure 3-5 *Compact center baluns such as these W2AU and Bencher items are truly beneficial for improving radiation patterns while minimizing feedline radiation and TV interference. The baluns are available in both 1:1 and 4:1 ratios.*

yoke's wire (which can be reused to make thin, low profile antennas), then wrap the acquired three-inch toroidal core with a layer of fiberglass or electrical tape for rigidity.

DO NEW ANTENNAS REALLY PERFORM BETTER THAN OLD ONES?

A large number of friends continue asking why recently installed wire antennas always seem to perform better than their older duplicates that once worked well until they broke or fell during harsh winter storms. Is there really a three-decibel advantage to new sky wires? What techniques are beneficial for retaining that "new antenna quality"? Does logic simply dictate biannual antenna updates? Most interesting questions indeed.

Investigations of both older antennas and similarly designed replacements of various types disclose some intriguing facts. All antennas perform their best and prove their DX worthiness when first installed. One half to two years later they "settle in" to an acceptable norm in a gradual manner seldom noticed. The antenna then continues to wear and deteriorate with time, a strand of wire snaps here or there, a balun's case cracks and allows water seepage, and connections corrode and loosen in the weather. Our prized sky wire is soon connected by only a few thin strands of wire. Its SWR rises ever so slightly, but we usually excuse that as wire stretching with age.

Meanwhile, the antenna's coaxial cable is attacked by strong ultraviolet rays from the sun and harsh chemicals in the soil. Metal roofs bake foam dielectrics like an outdoor oven, and pinches around gutters squeeze the cable until lumped impedance points are hopelessly excessive. Under these quite typical circumstances, we are actually doing well communicating with such worn antennas, and totally replaced copies obviously make a "daylight and dark" difference.

New wire, coaxial cable, balun and insulators use their full surface area. Rust and corrosion are not present to create losses or generate TVI. Cables are new and exhibit low loss. As enthusiastic radio amateurs, we also strive to make each sky wire better than the last. We measure their dimensions more accurately, use stronger insulators, install the antennas higher, and switch to Teflon-insulated plugs. Our expanded knowledge also inspires the inclusion of improved feed lines and routing. Yes, new sky wires do have an advantage over favorite old counterparts.

Looking more closely at those statements and comparing notes with authoritative antenna suppliers reveal yet more interesting points. Coaxial cable, for example, is not an item that typically can be tossed into a basement corner and stored for decades like old Acorn condensers and body-end-dot resistors. Its aging process begins at the time of manufacture rather than the time of actual installation. Comparing coaxial cable with produce in a grocery store may seem slightly unusual, but the relationship is undeniable. Fresh cable on an antenna makes a noticeable difference—but all cables are not created equal. Plastic or rubber jacketed cable laid on the ground is quickly damaged by alkali and chemicals. More recently designed cables have contamination resistant polyvinyl chloride jacketing which is not "biodegradable" producing longer life spans. Several kinds of antenna wire also tend to loosen strands and blacken with age, causing increased surface resistance and reduced radiation. The obvious question is how to assemble an antenna that retains its originally installed performance over the longest possible period of time.

Achieving long-term top performance from any antenna begins by selecting a top-grade wire, cable, balun and connectors.

See Figure 3-6. This consideration may involve a few more dollars initially, but it is actually less expensive in the long run. Next, generous use of a weatherproofing agent like Coax Seal® assures connection points and coaxial cable openings will not be damaged by weather. Dissimilar metals corrode when joined, and water in coaxial cable is disastrous. Removing and dissecting well-aged antenna connections wrapped in Coax Seal® produced an impressive fact: they were still shiny and new after many years use!

Removing excess cable strain on center connections and/or balun sockets is also vitally important. A long cable continuously pulling directly on a few wires in its connector is unavoidably susceptible to breakage. Support your connectors and coaxial cable and avoid wind flexing whenever possible. Finally, raise coaxial cable off the ground using any support at your disposal (e.g., wood chocks, inverted flower pots, etc.). Inside, cut off excess lengths of cable to minimize line losses and install Teflon-insulated connectors. The overall results will be an antenna with superb "initial installation performance" for the greatest possible length of time. Specific periods are not specified here because of climate variations from area to area. Exposed bolts on antenna supports near a salt water beach can rust in a week while those same items deteriorate little in dry Arizona areas. Let your personal knowledge, intuition and ingenuity be your guide!

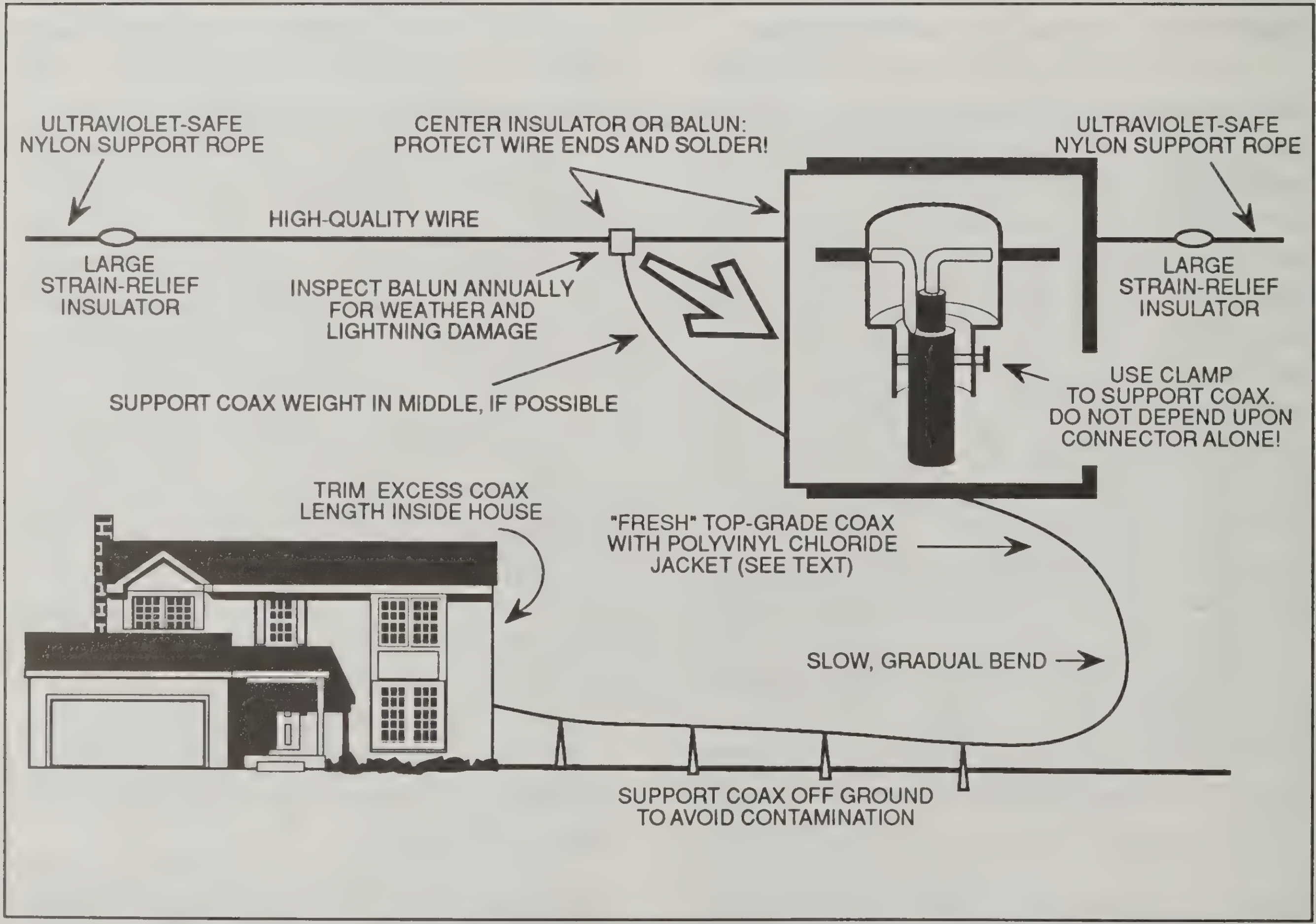

ULTRAVIOLET-SAFE NYLON SUPPORT ROPE
CENTER INSULATOR OR BALUN: PROTECT WIRE ENDS AND SOLDER!
ULTRAVIOLET-SAFE NYLON SUPPORT ROPE
HIGH-QUALITY WIRE
LARGE STRAIN-RELIEF INSULATOR
INSPECT BALUN ANNUALLY FOR WEATHER AND LIGHTNING DAMAGE
LARGE STRAIN-RELIEF INSULATOR
SUPPORT COAX WEIGHT IN MIDDLE, IF POSSIBLE
USE CLAMP TO SUPPORT COAX. DO NOT DEPEND UPON CONNECTOR ALONE!
TRIM EXCESS COAX LENGTH INSIDE HOUSE
"FRESH" TOP-GRADE COAX WITH POLYVINYL CHLORIDE JACKET (SEE TEXT)
SLOW, GRADUAL BEND
SUPPORT COAX OFF GROUND TO AVOID CONTAMINATION

Figure 3-6 *Outline for achieving long-term top performance from any wire antenna. Integrate as many of these ideas as possible for optimum results.*

CREATIVE METHODS OF ANTENNA INSTALLATION

Now let us consider one of the more challenging aspects of any wire antenna installation: how to erect and secure a radiator at some desired height while keeping at least one foot on the ground. The easiest way to accomplish this feat involves combining modern technology with personal skills. In other words, using a rod and reel, slingshot, or bow and arrow to propel an object (e.g., arrow, sinker, large bolt or nut, etc.) tied to a suitable length of light fishing line. If you are not proficient in the use of the previously mentioned items, you are encouraged to practice in open countryside away from homes, power lines, and people. After one or two hours practice, you probably will be able to "put a line" accurately over the top of any selected support or tree limb with only a few attempts.

I have personally found the new style of slingshots called "wristrockets" ideal for erecting wire antennas (they are fitted with surgical tubing rather than rubber bands and are available at most sporting goods stores). These powerful slingshots can quite easily propel a large bolt over 150 feet into the air with great accuracy. The following antenna installation idea exemplifies a wristrocket's use; however, you can substitute your own method of propulsion as desired.

Assuming you are comfortably accurate with your wristrocket or slingshot, begin antenna installation with a few practice shots over the desired supports or limbs (Be watchful of nearby houses, windows, autos, and yourself, and allow for ricochets. In addition, do not shoot into blinding sunlight.). When you feel sufficiently confident, connect one end of a long roll of inexpensive fishing line to the weight/sinker/bolt. Spread a substantial length of the line attached to the weight (i.e., the object being propelled) in front of you to avoid accidents or backlash. Be certain there is enough fishing line to extend from your position to well above the selected support or limb and back to the ground (also secure the line's spool or opposite end so it does not fly beyond your reach after the shot). Place the weight into the slingshot and lay the connected line through the forks of the slingshot and get ready to fire. Aim and fire, and watch your head. If you do not reach the desired branch, consider your odds for success before cutting the fishing line loose, retrieving the weighted end, recoiling the line, and trying again. Once you are successful, tie the antenna's supporting rope to the remaining end of the fishing line, then move to the line's weighted end and pull the rope (and antenna end) into position. After securing the rope and retrieving the fishing line and weight, you can perform the same feat for the other antenna support(s).

When pulling the antenna into final position, remember to allow plenty of leeway for the support/limb and antenna movement in both normal breezes and wind gusts. Some amateurs use light weights such as bricks on rope ends, others merely tie antenna retaining ropes where they can be lowered when not in use. Use your own ingenuity in this area.

Until recently, the technique of installing a wire antenna by using a bow and arrow to propel "pull-up lines" over high tree limbs was an unwieldy and rather hazardous procedure. That statement continues to have merit if you take a nonchalant attitude or an uninformed approach toward the procedure, but it changes dramatically when you add the advantage of modern technology. I, too, had several reservations about accurately controlling an arrow's flight until an outdoor sporting goods dealer demonstrated modern bows and arrows. With only a few hours of practice (preferably in the unpopulated countryside), you should be able to whisk a pull-up line over any selected high tree limb and have the arrow fall softly to the ground within a predetermined area.

The key to installing antennas with a bow and arrow is using modern and highly accurate equipment rather than homemade equivalents. Professional, lightweight bows, such as those used by sportsmen for fishing, are ideal. These compact bows are equipped with a fishing reel, and their high-test lines thread through the bow for easy use. Spear fishing bows typically cost between $40 and $100 new or $30 to $60 used. Used bows appear quite often in dealers stocks. If you presently own a lightweight bow, separate fishing reels that are simply taped on are also available from sporting goods stores. Their usual cost is $10 to $15. Avoid the ultra-expensive, big game hunting bows for antenna installation. Their "pull" and power are immense making them difficult to master for simple wire installations.

Sporting goods dealers also carry special soft-fall or "flu flu" arrows that zip high into the air then fall to earth like a graceful parachute. After a short period of practice, you can master the control of the flu-flu arrow's flight. Additionally, blunt rubber tips are available for flu-flu arrows which protect property as they return to terra firma. At first I was skeptical; however, after seeing a flu-flu arrow hit a polished white surface without leaving a mark, I was convinced otherwise.

Be sure to practice and perfect your "tree limb fishing" technique in a safe area before using it in your neighborhood. Be fast and accurate. Shoot with the sun at your back rather than in your face. Dawn and dusk are two good times because critical onlookers are usually not around. Plan your actions before carrying your bow and arrow outdoors. Know exactly where you will stand, how much "pull" will be required, and where your arrow should fall. Next, go to your launch spot with everything ready. Quickly recheck for safety, launch the arrow (with pull-up line attached), and retrieve it and the line's far end. Everything satisfactory? Return to the house, store the bow and arrow in a safe and inconspicuous place, then go back outdoors (any unnoticed onlookers will have given up watching for you to return). Secure your wire antenna's actual pull-up rope to the spear fishing line, then hoist everything into position. Simply remember safety first and, when in doubt, never take a chance. Properly handled bows and arrows are good antenna installing tools. Try this technique; you'll like it.

ANTENNA NOTES

CHAPTER FOUR

WIRE ANTENNAS FOR HF

INTRODUCTION

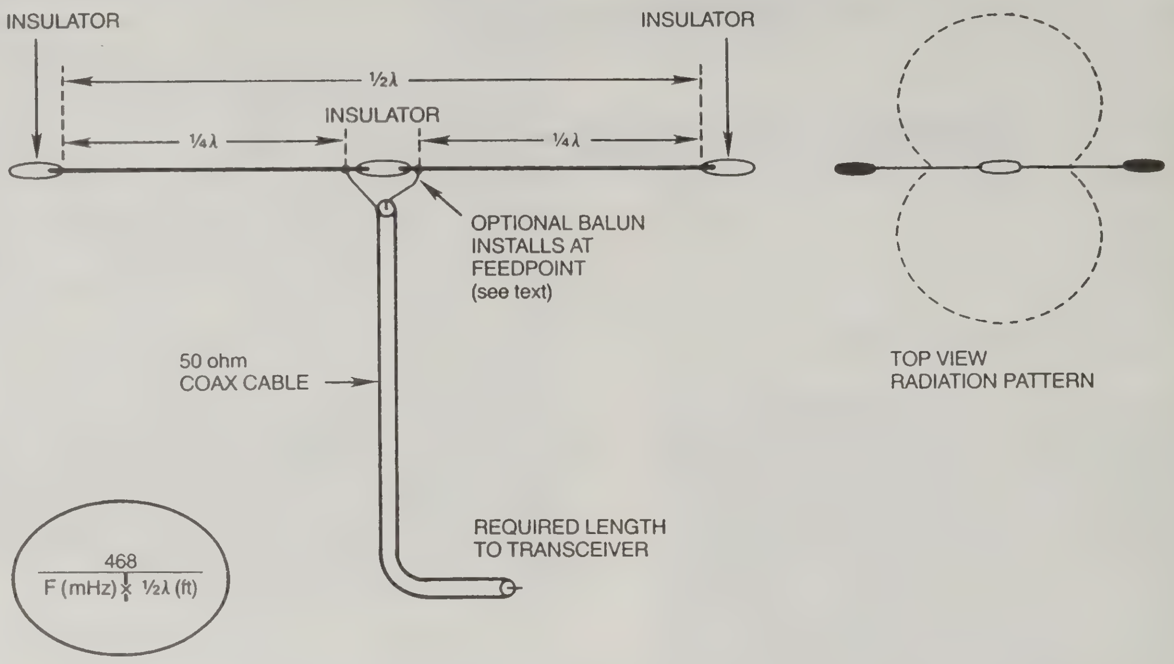
In order for any radio amateur to communicate successfully over the airways, an adequate signal must be radiated in order to reach desired or distant areas. This chapter is dedicated toward fulfilling that requirement by presenting ready-to-use information on a wide variety of basic, yet effective, wire antennas. We will use the concepts discussed in Chapter Three for determining and scaling measurements according to time-established formulas, and we will assume you have also reviewed previous chapter notes on influences of in-field items and feed-line considerations.

We also remind you this book's goal is to provide information which will get you on the air as easily and quickly as possible; however, for a more in-depth study of antennas and signal propagation, we suggest the technical publications readily available to all radio amateurs. This book provides the "basics" of antenna installation, assembly, and use; further technical and/or theoretical studies may follow according to your personal interests.

It should be realized that one form of basic antenna cannot necessarily be classified better than another because sky wire selection and use usually equates to what fits one's available area and installation capabilities. That is why many of us use different types and configurations of antennas. The true beauty of wire antennas shines through here because they are relatively flexible in layout, easily assembled and raised, they are inexpensive, and they are a radio amateur's prime form of self-expression. Now let us consider some of today's most popular wire radiators and get you communicating with those other radio amateurs from distant areas.

THE EVER-POPULAR BASIC DIPOLE

Probably the most common and popular antenna on our amateur HF bands is the basic dipole. It combines easy assembly with reasonably good performance. This antenna consists of a half wavelength of wire separated at its middle and is RF-fed by a two-conductor cable. Usual feed-point impedance varies between 50 and 75 ohms, thus establishing an acceptable match to 50-ohm cables such as RG58, RG8, or RG8X. Insulators are used at the middle of each end, and a non-conductive material such as nylon rope is suggested for suspension. If a popular commercial balun is used at the feed point (highly recommended for maximum performance), it can also serve as a center insulator. Baluns are quite useful for minimizing feed-line radiation and ensuring close-to-theoretical radiation patterns. They are available from several amateur radio equipment manufacturers.


INSULATOR
INSULATOR
½λ
INSULATOR
¼λ
¼λ
OPTIONAL BALUN INSTALLS AT FEEDPOINT (see text)
50 ohm COAX CABLE
REQUIRED LENGTH TO TRANSCEIVER
468
F (mHz) × ½λ (ft)
TOP VIEW RADIATION PATTERN
HALF WAVE FORM FOR DIPOLE

BAND	160 meters	80 meters	40 meters	30 meters	20 meters	18 meters	15 meters	12 meters	10 meters
FREQUENCY	1.820 mHz	3.750 mHz	7.100 mHz	10.100 mHz	14.100 mHz	18.100 mHz	21.100 mHz	24.900 mHz	28.600 mHz
OVERALL LENGTH (½λ)	257.14 ft.	124.82 ft.	65.91 ft.	46.33 ft.	33.19 ft.	28.85 ft.	22.18 ft.	18.79 ft.	16.36 ft.

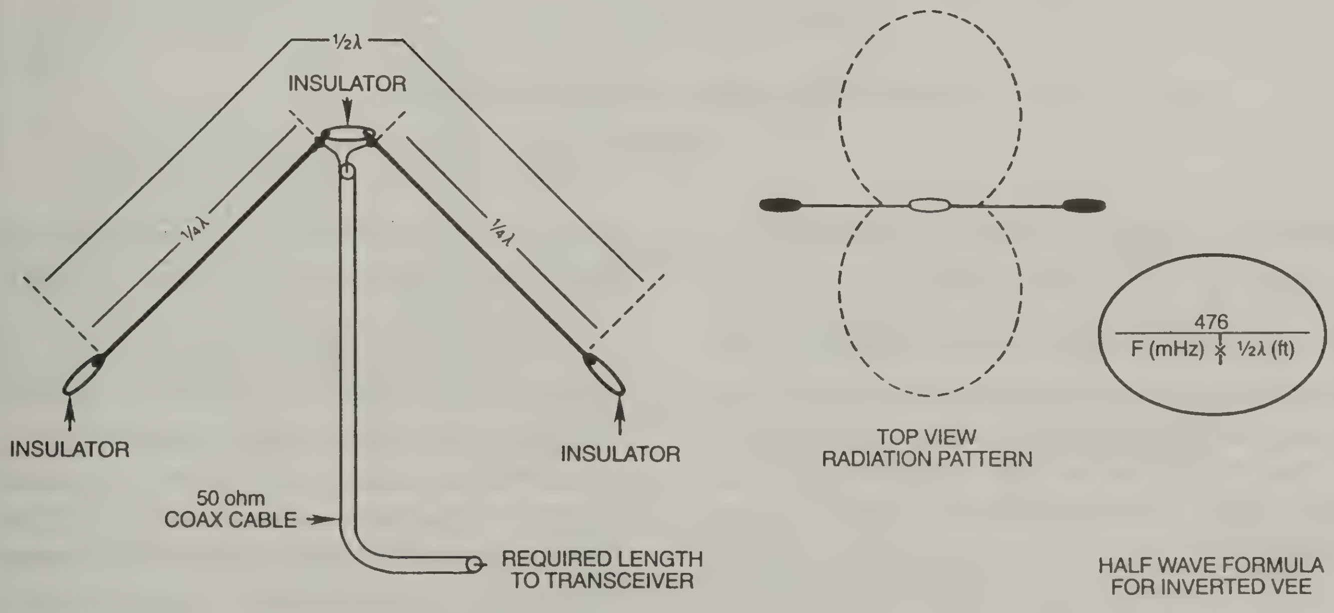
Figure 4-1 *Dipole dimensions for HF bands.*

In order for the dipole to perform satisfactorily, it should be placed at least one-fourth wavelength above ground and in a reasonably clear location. This height is not difficult to achieve for operation on frequencies above 14 mHz, but it may prove slightly challenging when hanging antennas for 40, 80, or 160 meters. As a consequence of low antenna positions, ground losses and/or high radiation angles may restrict some of the potentially useful RF energy. The obvious solution for individual situations is to simply mount antennas in the clear and as high as feasibly possible, then accept unavoidable limitations gracefully and enjoy the results.

Dipole dimensions for popular HF amateur bands are shown in **Figure 4–1**. These values may vary one or two percent depending on your particular antenna's height and location. Realizing that such variations may be experienced with almost any antenna, we suggest measuring both the resonant frequency (Remember our noise bridge discussion in Chapter One?) and SWR, and pruning the final length as required. After pruning the dipole's length and confirming its operation within the desired range, seal all exposed connections with Coax Seal® to ensure long and reliable performance. Note: This weather protection step is quite important and applies to all antennas. Dissimilar metals or wires joined together and exposed to moisture deteriorate rapidly. Likewise, exposed areas of coaxial cable absorb water and capillary action quickly spreads that moisture along the cable's length. Using tightly drawn electrical tape over the previously mentioned areas provides only temporary sealing. Ideas on installing wire antennas in trees with fishing lines and a rod and reel, bow and arrow, or wristrocket are included in the last part of Chapter Three.

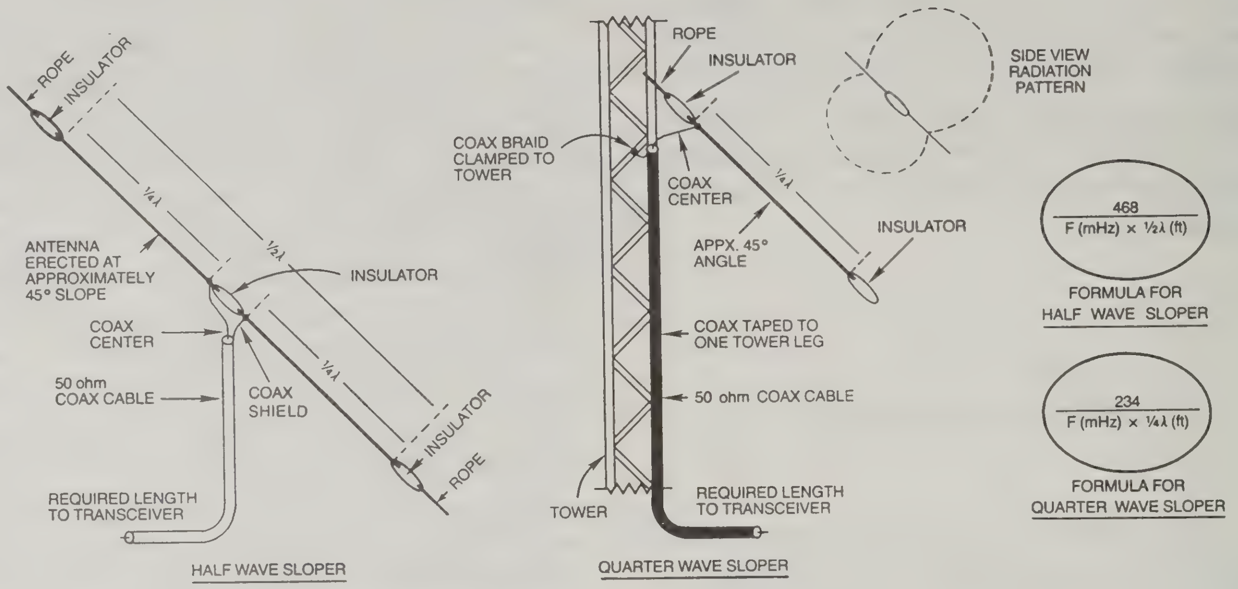
THE INVERTED VEE

The inverted vee is a slightly modified version of the classic dipole, and it is a rather impressive DX performer for limited space and support situations. Each of the radiating wires is angled downward, providing low-on-the-horizon signal radiation and reduced "end nulls" while permitting installation on a single center support. Because the antenna's ends are near the ground, final frequency pruning is also easy. Remember that a high voltage peak is present at the antenna's ends and position them above the reach of small children. The angled elements also affect their resonant frequency; therefore, slightly longer dimensions than ones for dipoles are used with the inverted vee. Inverted vee dimensions for popular HF amateur bands are included in **Figure 4–2**. Again, these values are subject to one or two percent variations with individual installations and encourage final pruning with a noise bridge and/or SWR meter for best results. A center balun is highly recommended for this antenna, and all ex-


½λ
INSULATOR
¼λ
¼λ
INSULATOR
INSULATOR
50 ohm COAX CABLE
REQUIRED LENGTH TO TRANSCEIVER
TOP VIEW RADIATION PATTERN
$\frac{476}{F\,(mHz)} = \frac{1}{2}\lambda\,(ft)$
HALF WAVE FORMULA FOR INVERTED VEE

BAND	160 meters	80 meters	40 meters	30 meters	20 meters	18 meters	15 meters	12 meters	10 meters
FREQUENCY	1.820 mHz	3.750 mHz	7.100 mHz	10.100 mHz	14.100 mHz	18.100 mHz	21.100 mHz	24.900 mHz	28.600 mHz
OVERALL LENGTH (½λ)	261.53 ft.	126.53 ft.	67.04 ft.	47.12 ft.	33.75 ft.	26.29 ft.	22.55 ft.	19.11 ft.	16.64 ft.

Figure 4-2 *Inverted vee dimensions for HF bands.*


ROPE
INSULATOR
¼λ
½λ
ANTENNA ERECTED AT APPROXIMATELY 45° SLOPE
INSULATOR
COAX CENTER
50 ohm COAX CABLE
COAX SHIELD
¼λ
INSULATOR
ROPE
REQUIRED LENGTH TO TRANSCEIVER
HALF WAVE SLOPER
ROPE
INSULATOR
COAX BRAID CLAMPED TO TOWER
COAX CENTER
¼λ
APPX. 45° ANGLE
INSULATOR
COAX TAPED TO ONE TOWER LEG
50 ohm COAX CABLE
TOWER
REQUIRED LENGTH TO TRANSCEIVER
QUARTER WAVE SLOPER
SIDE VIEW RADIATION PATTERN
468 / F (mHz) × ½λ (ft)
FORMULA FOR HALF WAVE SLOPER
234 / F (mHz) × ¼λ (ft)
FORMULA FOR QUARTER WAVE SLOPER

BAND	160 meters	80 meters	40 meters	30 meters	20 meters	18 meters	15 meters	12 meters	10 meters
FREQUENCY	1.820 mHz	3.750 mHz	7.100 mHz	10.100 mHz	14.100 mHz	18.100 mHz	21.100 mHz	24.900 mHz	28.600 mHz
HALF WAVELENGTH	257.14 ft.	124.82 ft.	65.91 ft.	46.33 ft.	33.19 ft.	25.85 ft.	22.18 ft.	18.79 ft.	16.36 ft.
QUARTER WAVELENGTH	128.57 ft.	62.40 ft.	33 ft.	23.16 ft.	16.6 ft.	12.9 ft.	11.2 ft.	9.5 ft.	8.2 ft.

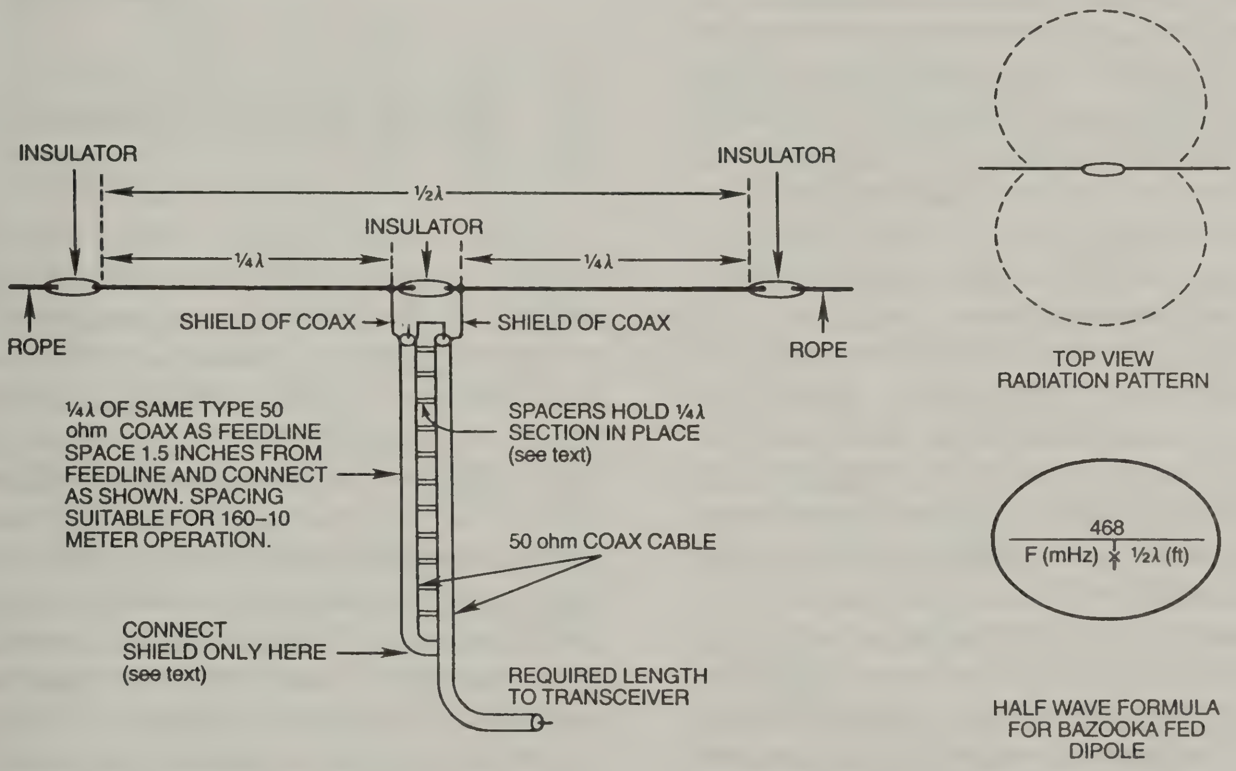
Figure 4-3 *Sloper antenna dimensions for HF bands.*

posed connections should be protected from the weather. In several ways, the inverted vee resembles a pair of leaning verticals RF-fed at their tops. Similarly, the inverted vee performs best when erected in a clear "horizontal view" of at least one-half wavelength in all directions. Numerous variations of this basic design are possible and open to your ingenuity.

THE SLOPER

An increasingly popular variation of the classic dipole is the sloper. This antenna may take one of two basic forms. It may be erected as a 35- to 55-degree angled half-wave dipole RF-fed in the center, or it may consist of a sloping quarter wavelength of wire RF-fed at the top and operated against the station's tower (A clever use of a guy wire.). Performance of either of the sloper's configurations is surprisingly good, and there is a slight degree of directivity in the direction of the slope. Some of the sloper's desirable points are use of a single support, creditable low-height performance, and the ability to aim a signal in preferred directions. A center balun is suggested for the half-wave sloper, otherwise the antenna's "upper quarter wavelength" should be connected to the (50 ohm) coaxial cable's center conductor. The upper support may be any convenient point such as a tree or tower. Because the radiation angle is low in the "forward" direction, the sloper is a fairly good single element DX antenna.

Sloper antenna dimensions for popular HF amateur bands are shown in **Figure 4–3**. Final length pruning with a noise bridge and SWR meter is again suggested for best returns. A certain amount of experimentation may be necessary when a quarter-wavelength sloper is installed and RF-operated against a tower. The feed line's center conductor is connected to the sloping wire, and its shield is connected to the tower. The optimum tower connection point usually appears where the wire slopes towards ground at a 45-degree angle. Moving that point experimentally and varying the quarter wave wire's end length usually adjusts SWR. Remember that aged and/or weathered tower sections may be corroded or the tower may be insulated between sections. Short heavy jumpers at each interfit point are suggested. Expansions such as single line coaxial switches, etc., are open to your creativity.


INSULATOR
INSULATOR
½λ
INSULATOR
¼λ
¼λ
ROPE
SHIELD OF COAX
SHIELD OF COAX
ROPE
¼λ OF SAME TYPE 50 ohm COAX AS FEEDLINE SPACE 1.5 INCHES FROM FEEDLINE AND CONNECT AS SHOWN. SPACING SUITABLE FOR 160–10 METER OPERATION.
SPACERS HOLD ¼λ SECTION IN PLACE (see text)
50 ohm COAX CABLE
CONNECT SHIELD ONLY HERE (see text)
REQUIRED LENGTH TO TRANSCEIVER
TOP VIEW RADIATION PATTERN
468
F (mHz) ✕ ½λ (ft)
HALF WAVE FORMULA FOR BAZOOKA FED DIPOLE

BAND	160 meters	80 meters	40 meters	30 meters	20 meters	18 meters	15 meters	12 meters	10 meters
FREQUENCY	1.820 mHz	3.750 mHz	7.100 mHz	10.100 mHz	14.100 mHz	18.100 mHz	21.100 mHz	24.900 mHz	28.600 mHz
OVERALL LENGTH (½λ)	257.14 ft.	124.82 ft.	65.91 ft.	46.33 ft.	33.19 ft.	25.85 ft.	22.18 ft.	18.79 ft.	16.36 ft.

Figure 4-4 *Bazooka-fed dipole dimensions and layout for HF bands.*

THE BAZOOKA-FED DIPOLE

When acquiring antenna materials, many amateurs tend to purchase more lengths of coaxial cable than necessary and store unused portions for later use. As time passes, that cable is often moved to unprotected locations where it may become damaged by moisture before use. We offer a logical alternative: incorporate that extra material into the antenna for radiating a better signal.

The bazooka-fed dipole is inexpensive and easy to assemble and has a reputation of radiating HF signals in fine style. Its original design centered around 80- or 40- meter operations, but its measurements can be easily scaled for other bands such as 160 or 30 meters as desired. Old timers may remember this sky wire as the "Collins Antenna" and, like that classic gear, its performance is quite impressive.

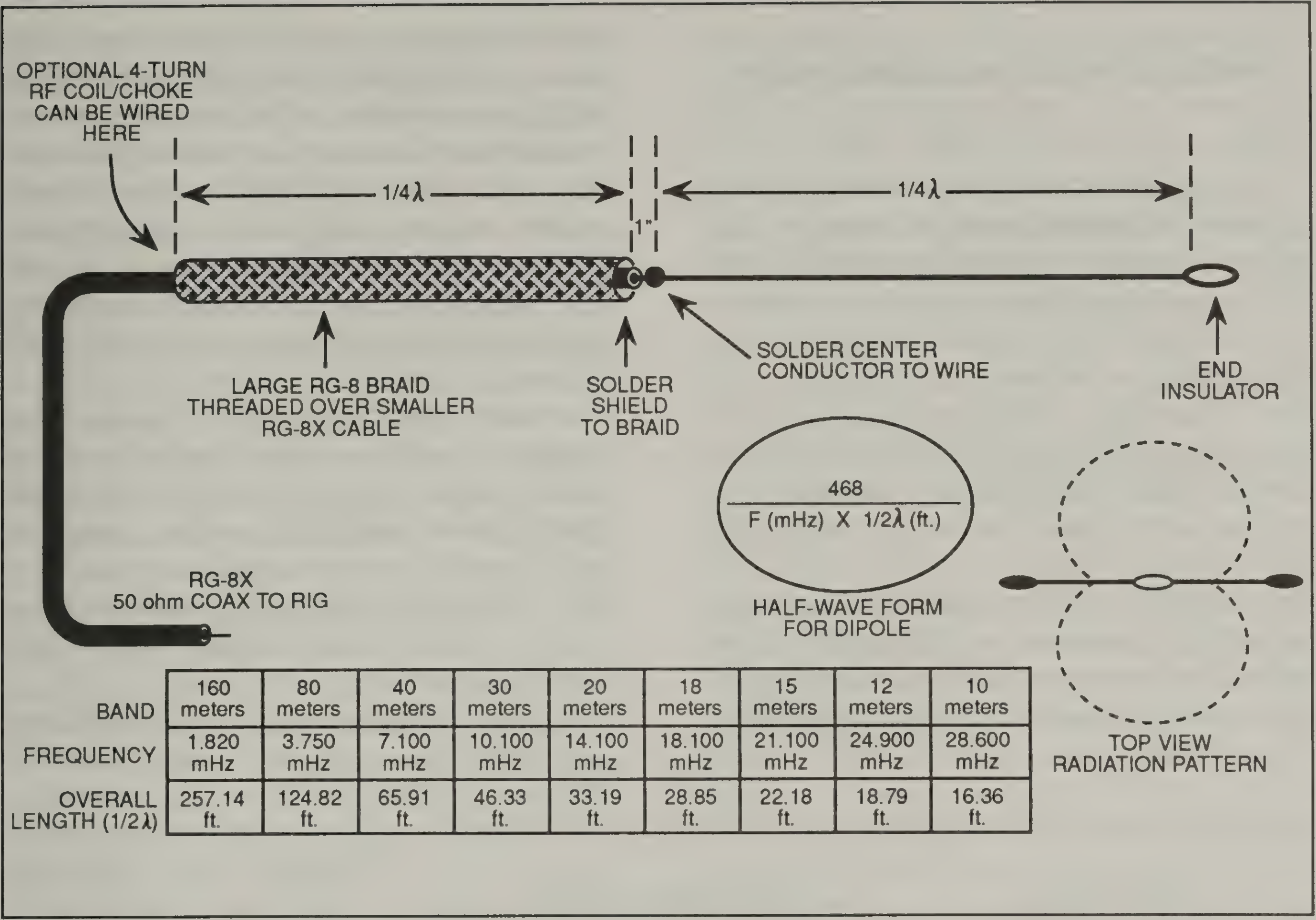
The bazooka-fed dipole's dimensions and layout are shown in **Figure 4–4**. Essentially, this is a conventional style dipole with an "open air" balun (which incidentally, enjoyed high popularity before the days of small commercial baluns). The quarter-wave balun section is made from a length of the same 50-ohm cable which connects the antenna to its associated station gear. It is spaced 1.5 inches from the "main cable" and secured roughly every 10 inches with homemade or improved spacers of wood or plastic. The spacers can be elaborate (wooden blocks boiled in paraffin with holes drilled to fit the coaxial cable) or as simple as desired (hardware store plastic clips taped to coaxial lines). Notice the feed line and balun interconnections in **Figure 4–4**. Only the balun's shield is electrically connected to the antenna with the feed line's center connecting to one end and both shields interconnecting at the "lower end." Be careful when soldering coaxial lines, especially the "lower" connection, otherwise you can damage the inner dielectric. An ample wrapping of "Coax Seal" is definitely advised on all coaxial connections to prevent moisture damage and early failure of this superb antenna.

At first glance, it may appear "both sides" of the antenna are connected to feed-line shields. Balun action, however, ensures "both sides" are RF-fed to produce a well radiated signal of which you can be justifiably proud. Remember to erect the antenna high enough to allow the balun section to "drop" directly below the antenna and "end" at least six feet above the ground, then enjoy the excellent performance of this classic radiator.

THE END-FED COAX DIPOLE

When I operate on 30 meters from an unfamiliar beach cottage or condo, Murphy always ensures there is only one available support for antennas. Because of this problem, I created the roll-up dipole illustrated in **Figure 4-5**. This lightweight antenna can be assembled for operation on any desired HF band; it can be mounted horizontally, vertically or sloping; and its "full-size" dimensions yield superb performance. You can even spray the wires with blue and gray paint for camouflaging or "invisible" antenna use from an apartment balcony or window.

The antenna is assembled by first connecting a quarter wavelength of insulated hookup wire to the center conductor of an RG-8X cable. Wire gauges of number 16 to 14 are lightweight, yet strong enough for portable use. A quarter wavelength of braid salvaged from a larger RG-8 coaxial cable is then threaded over the smaller RG-8X cable and the shields are connected at the center feed point. Because the antenna's feed line extends from one end rather than the center,


OPTIONAL 4-TURN RF COIL/CHOKE CAN BE WIRED HERE
1/4λ
1"
1/4λ
LARGE RG-8 BRAID THREADED OVER SMALLER RG-8X CABLE
SOLDER SHIELD TO BRAID
SOLDER CENTER CONDUCTOR TO WIRE
END INSULATOR
468 / F (mHz) X 1/2λ (ft.)
HALF-WAVE FORM FOR DIPOLE
RG-8X 50 ohm COAX TO RIG
TOP VIEW RADIATION PATTERN

BAND	160 meters	80 meters	40 meters	30 meters	20 meters	18 meters	15 meters	12 meters	10 meters
FREQUENCY	1.820 mHz	3.750 mHz	7.100 mHz	10.100 mHz	14.100 mHz	18.100 mHz	21.100 mHz	24.900 mHz	28.600 mHz
OVERALL LENGTH (1/2λ)	257.14 ft.	124.82 ft.	65.91 ft.	46.33 ft.	33.19 ft.	28.85 ft.	22.18 ft.	18.79 ft.	16.36 ft.

Figure 4-5 *The end-fed coax dipole. This roll-up antenna is ideal for apartment dwellers and vacationers.*

it easily fits into previously impossible locations.

The main factors to remember when assembling this antenna are removing stress at the center feed point and being patient while threading small coaxial cable through the larger braid. A small loop of one or two turns of the hookup wire can be taped securely to the RG-8X's jacket to relieve strain, or else devise a clever stress-efficient center insulator. Personal ingenuity is paramount. Keep the larger RG-8 braid loose and short for easy threading, then stretch it tight and remeasure and prune its length for your desired band. Cover the exposed braid with a smooth even spiraling wrap of electrical tape, being sure the antenna's "transmitter end" stays at the correct length. Finally, weatherproof the center feed point to ensure moisture does not enter the RG-8X cable.

If desired, an optional RF choke consisting of four to six turns of the feed line/RG-8X cable can be wound into a six-inch diameter loop at the RG-8 shield's "transmitter end" to minimize possible feed line radiation.

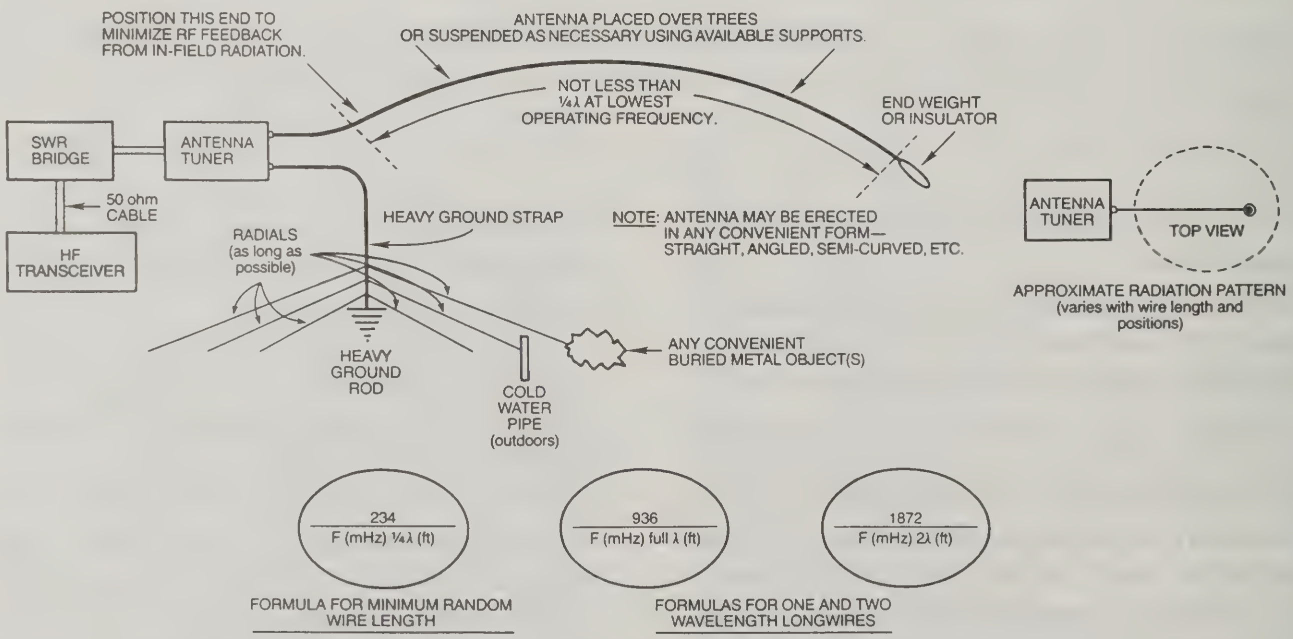
Knowledge of various radiators and their means of installation is important to all amateurs. Knowing your options, so to speak, is the key to getting on the air from any location. Remember this sky wire. It may be your perfect answer to antenna aspirations in the future.

RANDOM WIRES AND LONG WIRES

If you have ever been faced with the problem of getting operational on a new band during inclement weather or quickly setting up a temporary antenna for use at a portable location, you have surely considered using the random wire antenna. Preferably, the wire should be at least one-quarter wavelength for its lowest operating frequency and consist of a single convenient length radiator erected across tree tops using a slingshot or rod and reel. The wire (which may be of various sizes, insulated or non insulated, according to available material and employed RF power) is used with a good earth ground and antenna tuner to produce easy operation with almost any modern transceiver. The random wire's performance is directly related to its ground system's effectiveness, and that ground should also be connected to the utilized tuner. Cold water pipes and a single ground rod near the station setup make a good starting point with additional ground rods, radials, and buried (or unburied) metal objects of any kind noticeably improving overall antenna efficiency.

Initially, when setting up the random wire antenna, avoid exposed lengths in areas where anyone might come in contact with RF energy. Because basically all of the wire's area radiates, it is also advisable to start out with a 45-degree tilt moving away from the tuner to minimize the possibility of RF feedback or a "hot" setup.

General details regarding random wires


POSITION THIS END TO MINIMIZE RF FEEDBACK FROM IN-FIELD RADIATION.
ANTENNA PLACED OVER TREES OR SUSPENDED AS NECESSARY USING AVAILABLE SUPPORTS.
NOT LESS THAN ¼λ AT LOWEST OPERATING FREQUENCY.
END WEIGHT OR INSULATOR
SWR BRIDGE
ANTENNA TUNER
50 ohm CABLE
HF TRANSCEIVER
HEAVY GROUND STRAP
RADIALS (as long as possible)
NOTE: ANTENNA MAY BE ERECTED IN ANY CONVENIENT FORM—STRAIGHT, ANGLED, SEMI-CURVED, ETC.
HEAVY GROUND ROD
COLD WATER PIPE (outdoors)
ANY CONVENIENT BURIED METAL OBJECT(S)
ANTENNA TUNER
TOP VIEW
APPROXIMATE RADIATION PATTERN (varies with wire length and positions)
234 / F (mHz) ¼λ (ft)
936 / F (mHz) full λ (ft)
1872 / F (mHz) 2λ (ft)
FORMULA FOR MINIMUM RANDOM WIRE LENGTH
FORMULAS FOR ONE AND TWO WAVELENGTH LONGWIRES

BAND	160M	80M	40M	30M	20M	18M	15M	12M	10M
FREQUENCY	1.820 mHz	3.750 mHz	7.100 mHz	10.100 mHz	14.100 mHz	18.100 mHz	21.100 mHz	24.900 mHz	28.600 mHz
¼ WAVELENGTH	128.57 ft.	62.40 ft.	32.96 ft.	23.16 ft.	16.6 ft.	12.9 ft.	11.09 ft.	9.4 ft.	8.18 ft.
FULL WAVELENGTH	514.29 ft.	249.60 ft.	131.83 ft.	92.67 ft.	66.38 ft.	51.71 ft.	44.36 ft.	37.59 ft.	32.73 ft.
TWO WAVELENGTHS	1028.6 ft.	499.20 ft.	263.66 ft.	185.34 ft.	132.76 ft.	103.42 ft.	88.72 ft.	75.18 ft.	64.45 ft.

Figure 4-6 *Random and long wire antennas.*

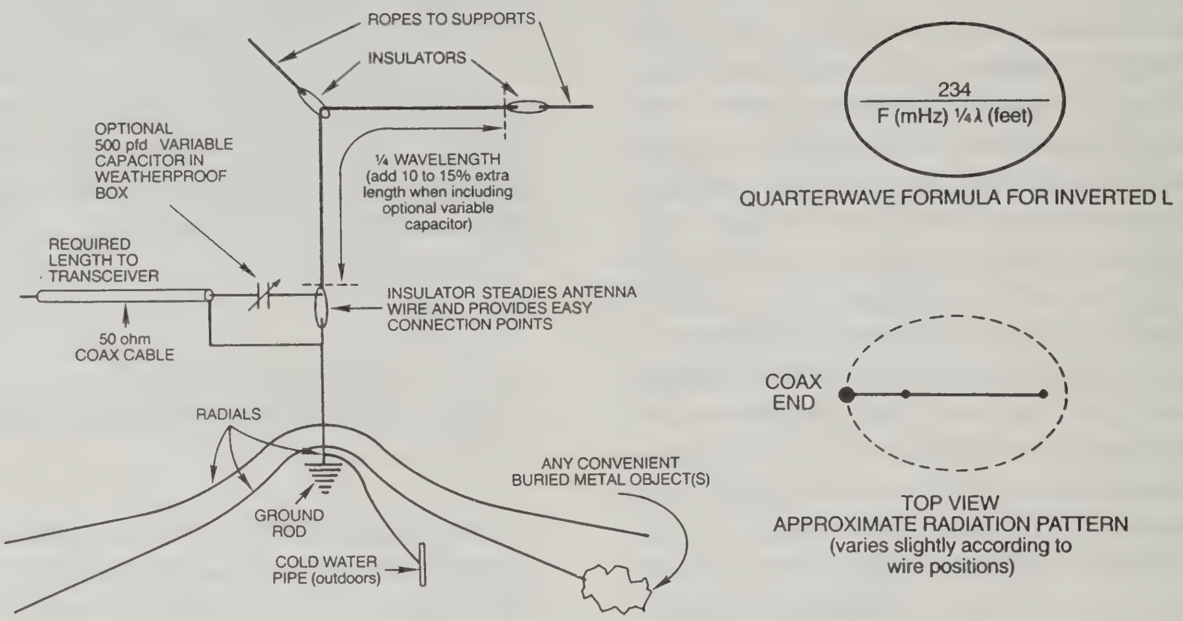
and long wires are shown in **Figure 4–6**. In many ways, it is difficult to specify exactly where the term "random" ends and "long wire" begins. Indeed, many radio amateurs use these terms quite interchangeably. We personally prefer designating single wire radiators one wavelength or longer at their frequency of operation as "long wires," with ensuing lengths exceeding two wavelengths as "long, long wires" (Actually, they are all basic end-fed antennas). We might also mention that random and/or long wires can further prove to be good multiband antennas for frequencies above their quarter wavelength (For example: Approximately a 65-foot wire is capable of operation on 80, 40, 30, 20, 17, 12, and 10 meters with, naturally, a tuner.). Could such basic (and often unmeasured) wires actually prove to be effective DX sky wires? We have known many amateurs who have used them in a variety of locations and positions, and they have always echoed an encouraging, "Yes, indeed."

What is the best way to tune a random wire or long wire antenna? First begin by ensuring the best obtainable ground system has been provided and solidly connected to the station's antenna tuner. While listening to the station's receiver, set the tuner's capacitors to mid range and then adjust the tuner's coil for maximum reception. Once that peak is found, "tweak" reception with each capacitor. Next apply a small amount of RF energy from the transmitter and fine tune the tuner's variable capacitors while monitoring SWR. Remember to switch off RF output before changing tuner coil taps/positions, otherwise damage from arcing may damage the station's transmitter or tuner. Alternately, a deluxe noise bridge can be preset to 50 ohms and inserted between the tuner and transmitter for fully quiet and no-transmitted RF tune-up. Although frequencies below the wire's quarter wavelength may be covered with a random antenna, their related tuner adjustments can be slightly tricky. We might also add that an antenna's transmitting and receiving performance is directly proportional to its capture area or radiation surface area. Both a 12-foot wire and a 120-foot wire may be used on a particular HF band through the incorporation of an antenna tuner, but the longer length simply offers more pure radiation area for producing and capturing signals.

THE INVERTED "L" AND THE TWIN-LEAD MARCONI

There are two interesting variations of the random and long wire antennas which over time have proven their worth to radio amateurs: the inverted "L" and the twin-lead Marconi. Although these antennas are primarily used on lower frequency bands such as 80 or 160 meters, they can easily be dimensioned for higher frequency bands to accommodate one's available space or operating plans. The keynote, as always, involves installing them as high and as much in the clear as possible. The inverted "L" differs from a random wire antenna in two obvious ways: a resonant quarter wavelength of wire is used instead of an unmeasured or random length of wire, and the antenna is usually erected in a tilted "L" position. Another difference is the exclusion of an antenna tuner and the utilization of 50-ohm coaxial cable for connection to the station's transceiver. Ground losses are prime considerations of the inverted "L" antenna so, unless your station is setup in the middle of a swamp, one or two long radials and a good cold water pipe connection are strongly suggested as a "minimum ground."

Dimensions and layout of the inverted "L" are shown in **Figure 4–7**. You can cut the wire according to its quarter-wave formula's length or incorporate the clever "WIBB method" of including an extra ten to fifteen percent length and installing a weather protected tuning



BAND	160M	80M	40M	30M	20M	18M	15M	12M	10M
FREQUENCY	1.820 mHz	3.750 mHz	7.100 mHz	10.100 mHz	14.100 mHz	18.100 mHz	21.100 mHz	24.900 mHz	28.600 mHz
OVERALL LENGTH (¼λ)	128.57 ft.	62.40 ft.	32.96 ft.	23.16 ft.	16.60 ft.	12.93 ft.	11.09 ft.	9.40 ft.	8.18 ft.

NOTE: ADD 10 – 15% TO ABOVE LENGTHS IF OPTIONAL VARIABLE CAPACITOR IS USED.

Figure 4-7 *Inverted "L" dimensions and layout for HF bands.*

capacitor at its ground base. The latter idea can simplify back-and-forth prunings for low SWR on band-edge transmissions, and the capacitor's position(s) can be marked for quick ground level changes. A 500-pfd variable capacitor is quite suitable for 160-meter operation, and that value is also applicable for use through 10 meters. Remember to use a capacitor with sufficient plate spacing to handle your particular RF power level and include a good ground using every available grounding possibility (e.g., sprinkler system, fences, buried objects, etc.).

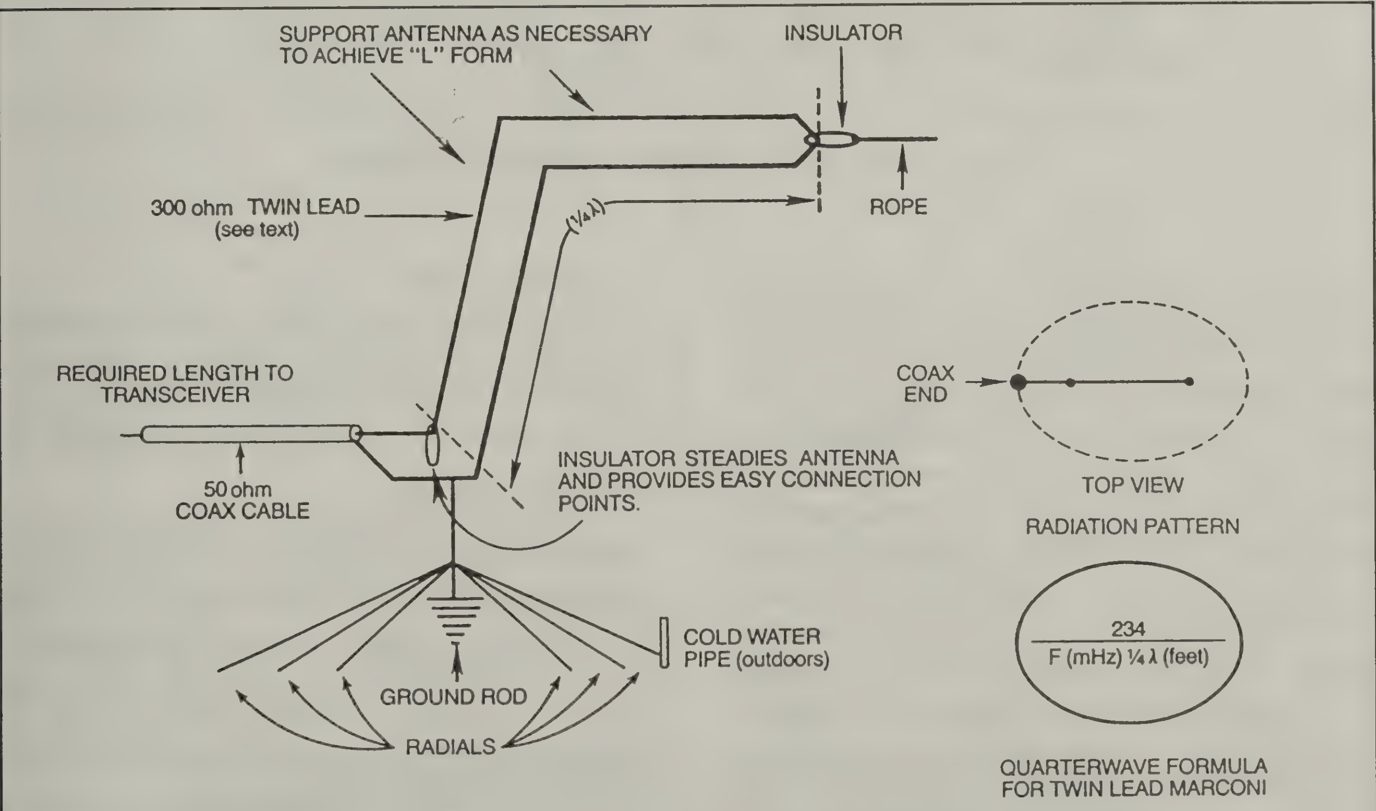
The twin-lead Marconi is an often overlooked but rather attractive low-cost radiator. Indeed, one well known antenna manufacturer previously produced a multiband/trap version of the twin-lead Marconi which was used and enjoyed by a number of radio amateurs. An interesting aspect of this antenna is its improvement in radiation resistance by placing its "other part" in the sky beside the "main wire," thus exhibiting a feed-point impedance between 40 and 50 ohms.

Dimensions and layout for the twin-lead Marconi antenna are included in **Figure 4–8**. The radiator is made of 300-ohm TV twin lead which is shorted at the "far" end and connected between coaxial cable center and shield at the RF-fed end. The previously mentioned commercial version of this antenna used open-air-type 450-ohm line. Try to "run it" away from the station's gear rather than above it to minimize RF-feedback possibilities. As usual, a good ground system is the final touch for successful results.

VERTICALS AND GROUND PLANES OF WIRE

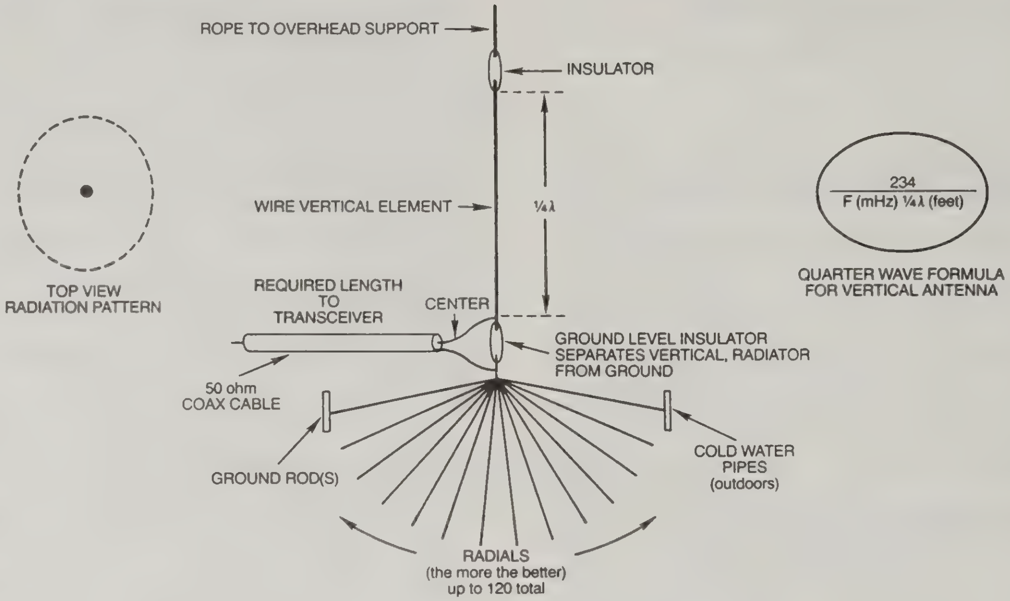
Two very popular antennas among amateurs with limited space and/or time for installing larger arrays are the traditional quarter-wave vertical and the ground plane antennas. These radiators usually consist of an aluminum tubing "upper section" with wire radials; however, almost equal results can be achieved by constructing the entire antenna from available wire. The only noticeable tradeoff is slightly reduced bandwidth capability due to smaller diameter wire replacing large surface area tubing (100 kHz at less than 2:1 SWR, typically). Properly installed verticals and ground planes have a long reputation as good DX antennas for their cost, and the key to enjoying that performance entails knowing how to install them correctly. This involves the utilized system, radiator height above ground (in the case of a straight vertical, that is the antenna's "center connection"), and its vitally important unobstructed view toward the horizon. Place a vertical without radials in a rocky valley surrounded by trees, and it will perform poorly. Place a vertical with radials on a flat beach by the sea and it will work beautifully. A "clear view" and a good radial system is everything to these antennas.

Vertical antenna dimensions for popular HF amateur bands are shown in **Figure 4–9**. The vertical element itself is insulated from the ground, while the network of ground radials create a "mirror image" of the vertical to complete the antenna system. A minimum of


SUPPORT ANTENNA AS NECESSARY TO ACHIEVE "L" FORM
INSULATOR
ROPE
300 ohm TWIN LEAD (see text)
(¼λ)
REQUIRED LENGTH TO TRANSCEIVER
50 ohm COAX CABLE
INSULATOR STEADIES ANTENNA AND PROVIDES EASY CONNECTION POINTS.
COAX END
TOP VIEW
RADIATION PATTERN
COLD WATER PIPE (outdoors)
GROUND ROD
RADIALS
234 / F (mHz) ¼ λ (feet)
QUARTERWAVE FORMULA FOR TWIN LEAD MARCONI

BAND	160M	80M	40M	30M	20M	18M	15M	12M	10M
FREQUENCY	1.820 mHz	3.750 mHz	7.100 mHz	10.100 mHz	14.100 mHz	18.100 mHz	21.100 mHz	24.900 mHz	28.600 mHz
OVERALL LENGTH (¼λ)	128.57 ft.	62.40 ft.	32.96 ft.	23.16 ft.	16.60 ft.	12.93 ft.	11.09 ft.	9.40 ft.	8.18 ft.

Figure 4-8 *Twinlead Marconi dimensions and layout for HF bands.*


ROPE TO OVERHEAD SUPPORT
INSULATOR
WIRE VERTICAL ELEMENT
¼λ
234
F (mHz) ¼λ (feet)
QUARTER WAVE FORMULA FOR VERTICAL ANTENNA
TOP VIEW RADIATION PATTERN
REQUIRED LENGTH TO TRANSCEIVER
CENTER
GROUND LEVEL INSULATOR SEPARATES VERTICAL, RADIATOR FROM GROUND
50 ohm COAX CABLE
GROUND ROD(S)
COLD WATER PIPES (outdoors)
RADIALS (the more the better) up to 120 total

BAND	160M	80M	40M	30M	20M	18M	15M	12M	10M
FREQUENCY	1.820 mHz	3.750 mHz	7.100 mHz	10.100 mHz	14.100 mHz	18.100 mHz	21.100 mHz	24.900 mHz	28.600 mHz
VERTICAL RADIATOR	128.57 ft.	62.40 ft.	32.96 ft.	23.16 ft.	16.60 ft.	12.93 ft.	11.09 ft.	9.40 ft.	8.18 ft.
RADIALS (5% LONGER)	135.00 ft.	65.52 ft.	34.61 ft.	24.32 ft.	17.43 ft.	13.60 ft.	11.64 ft.	9.87 ft.	8.60 ft.

Figure 4-9 *Vertical antenna dimensions and layout for HF bands.*

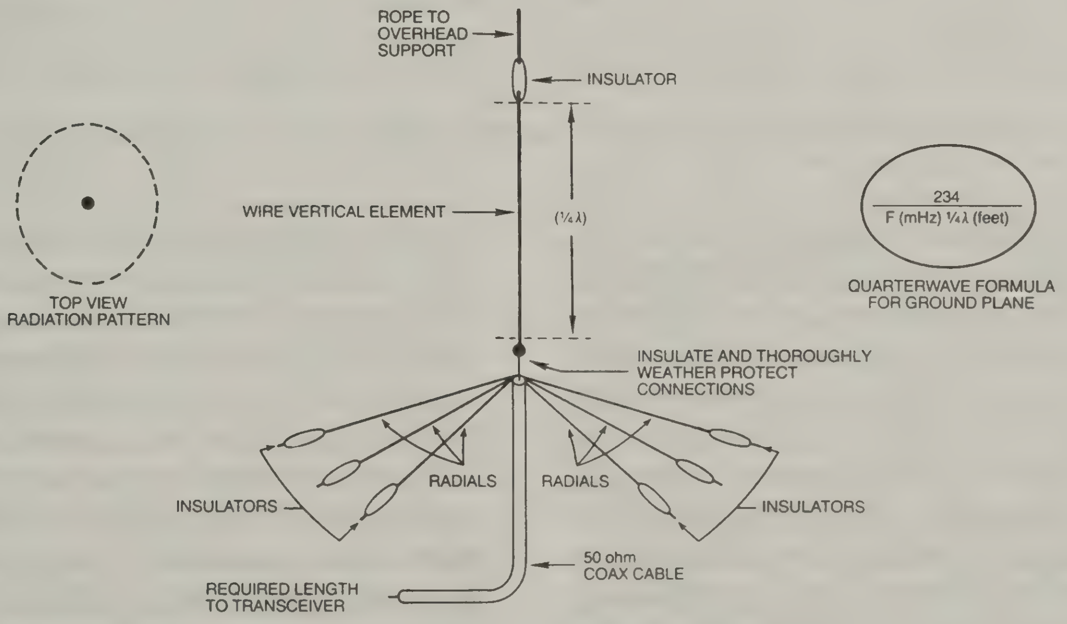
six radials should be buried a few inches below the ground, with the primary thought being "the more the better"—up to 120 radials placed in a "spoke" pattern from the vertical's feed point. A noticeable improvement, which many amateurs describe as a three-decibel gain, can be realized when radial lengths are extended from ¼ to ½ wavelength for their operating frequency. As previously mentioned, a vertical antenna must not be placed in a horizon-restricted position to perform successfully. A vertical radiator mounted atop a 30- or 40-foot metal pipe, however, is not truly a "vertical," but rather an off-center fed and questionably resonant vertical dipole (remember our previous words concerning a vertical's feed point). If it is impossible to provide a fully clear view for the vertical, consider a ground plane antenna or select a position for erecting the vertical which favors the desired communications directions as much as possible.

The quarter-wave ground plane is an attractive variation of the vertical antenna, and a quite popular sky wire among 80-, 40-, and 30-meter enthusiasts. The vertical radiator is usually aluminum tubing; however, wire hung from tree limbs or strapped to bamboo or fiberglass poles works just as well. This is a good low band DX antenna worthy of consideration by anyone with budget or space restrictions. It is easy to install and maintain, and assuming it is mounted above nearby surrounding objects, it will surely give impressive results.

Ground plane dimensions for popular HF amateur bands are shown in **Figure 4–10**. The radials (at least four are suggested) may be antenna or hookup wire, and should be drooped at a 30- to 50-degree angle for best results and near a 50-ohm cable match. Many amateurs report good results with ground planes of wire raised above house roofs with radials laid only a few inches above the roof and the end secured with bricks for anchors. A number of expansions are possible in vertical and ground plane designs, so feel free to add personal touches according to your ingenuity. If you ultimately produce a better radiator, great! Share the knowledge. This is one area where radio amateurs have always excelled, giving the "impossible" one more try. Your experimentation may yield returns impossible with commercial antennas.

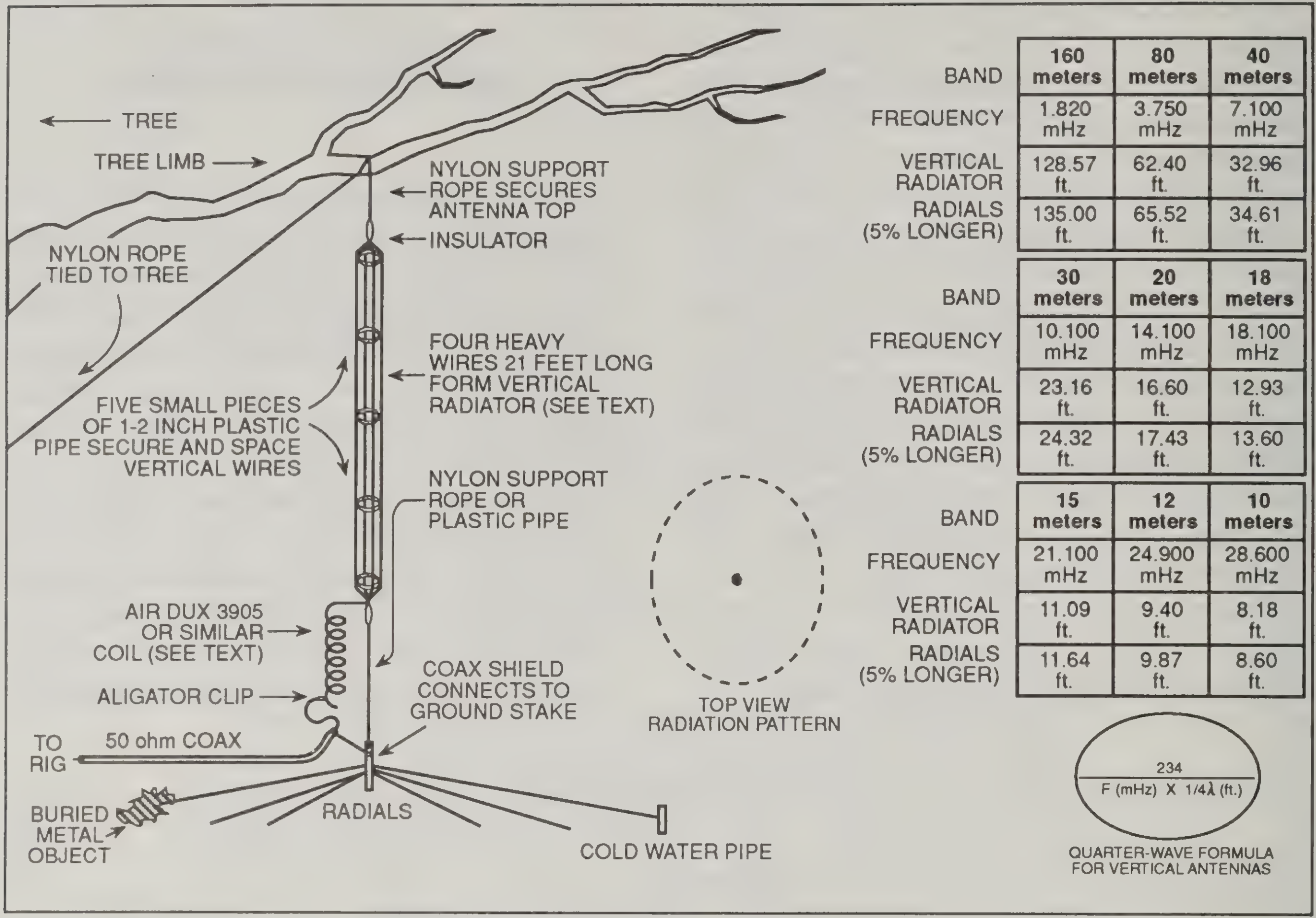
WORK THE WORLD WITH THIS WIRE VERTICAL

Many years ago when rigs glowed with the soft warmth of vacuum tubes and amber half-moon dials, an antenna company known as Gotham manufactured a 21-foot, all-band vertical antenna. Its attractive ads captured my attention, but the antenna was simply beyond my pre-teenage allowance. If I had only known a homemade version of that antenna could have been assembled from wire and a B&W coil, DXing would have surely been possible. The following antenna fulfills that dream and restores the beauty of times past. This 21-foot "vertical" is suspended from a low tree branch, employs a


ROPE TO OVERHEAD SUPPORT
INSULATOR
WIRE VERTICAL ELEMENT
(¼λ)
TOP VIEW RADIATION PATTERN
234 / F (mHz) ¼λ (feet)
QUARTERWAVE FORMULA FOR GROUND PLANE
INSULATE AND THOROUGHLY WEATHER PROTECT CONNECTIONS
RADIALS
RADIALS
INSULATORS
INSULATORS
50 ohm COAX CABLE
REQUIRED LENGTH TO TRANSCEIVER

BAND	160M	80M	40M	30M	20M	18M	15M	12M	10M
FREQUENCY	1.820 mHz	3.750 mHz	7.100 mHz	10.100 mHz	14.100 mHz	18.100 mHz	21.100 mHz	24.900 mHz	28.600 mHz
VERTICAL RADIATOR	128.57 ft.	62.40 ft.	32.96 ft.	23.16 ft.	16.60 ft.	12.93 ft.	11.09 ft.	9.40 ft.	8.18 ft.
RADIALS (5% LONGER)	135.00 ft.	65.52 ft.	34.61 ft.	24.32 ft.	17.43 ft.	13.58 ft.	11.63 ft.	9.87 ft.	8.60 ft.

Figure 4-10 *Ground plane dimensions and layout for HF bands.*


TREE
TREE LIMB
NYLON ROPE TIED TO TREE
NYLON SUPPORT ROPE SECURES ANTENNA TOP
INSULATOR
FOUR HEAVY WIRES 21 FEET LONG FORM VERTICAL RADIATOR (SEE TEXT)
FIVE SMALL PIECES OF 1-2 INCH PLASTIC PIPE SECURE AND SPACE VERTICAL WIRES
NYLON SUPPORT ROPE OR PLASTIC PIPE
AIR DUX 3905 OR SIMILAR COIL (SEE TEXT)
ALIGATOR CLIP
COAX SHIELD CONNECTS TO GROUND STAKE
TO RIG
50 ohm COAX
BURIED METAL OBJECT
RADIALS
COLD WATER PIPE
TOP VIEW RADIATION PATTERN
234
F (mHz) X 1/4λ (ft.)
QUARTER-WAVE FORMULA FOR VERTICAL ANTENNAS

BAND	160 meters	80 meters	40 meters
FREQUENCY	1.820 mHz	3.750 mHz	7.100 mHz
VERTICAL RADIATOR	128.57 ft.	62.40 ft.	32.96 ft.
RADIALS (5% LONGER)	135.00 ft.	65.52 ft.	34.61 ft.

BAND	30 meters	20 meters	18 meters
FREQUENCY	10.100 mHz	14.100 mHz	18.100 mHz
VERTICAL RADIATOR	23.16 ft.	16.60 ft.	12.93 ft.
RADIALS (5% LONGER)	24.32 ft.	17.43 ft.	13.60 ft.

BAND	15 meters	12 meters	10 meters
FREQUENCY	21.100 mHz	24.900 mHz	28.600 mHz
VERTICAL RADIATOR	11.09 ft.	9.40 ft.	8.18 ft.
RADIALS (5% LONGER)	11.64 ft.	9.87 ft.	8.60 ft.

Figure 4-11 *Work the world wire vertical. This system operates 160 through 10 meters with surprisingly good results.*

large base loading coil to tune all bands from 160 through 10 meters, including WARC frequencies, and it performs just as well today as its counterpart of yesteryear. This design is ideal for apartment dwellers, vacationers, and amateurs needing to maintain a low profile. It is also a good means for "testing the waters" of previously overlooked bands before erecting a more elaborate antenna.

As shown in **Figure 4-11**, the antenna's radiator consists of four closely spaced wires shorted at both ends and separated by pieces of small diameter plastic pipe to electrically simulate aluminum tubing. Only one wire can be used if necessary; however, the antenna will simply be less broad banded and require more coil tap adjustments at band ends.

The large base coil is 2 ¼ inches in diameter, with 10 turns per inch, and 6 to 10 inches long. Air Dux manufactures a number 3905 coil (many similar equivalents can also be used), or you can simply wind your own using number 12- or 14-gauge wire. Use tinned wire double spaced so you can experimentally tap turns for tuning. An approximate 8-inch length of number 12 or 14 stranded wire soldered to the coaxial cable's center conductor on one end and an alligator clip on the other end is used for coil tapping. The coil's lower end may be connected to ground for 40- through 10-meter use plus lightning protection if desired. Since most of the coil's length is usually required for 80- and 160-meter operation, the ground connection should be removed for "low band" use.

An effective ground system is very important to this antenna's performance. At least 12 radials, 60 to 70 feet in length, should be laid on or buried two inches below the ground and connected to the antenna's ground stake and coaxial cable shield. Use every metallic item at your disposal to create a good ground: cold water pipes, small fences, buried bicycles or autos, anything. Finally, install the antenna so its lower end (and coil) are not more than four feet above ground. This measure ensures that the antenna is a true vertical rather than an off-center-fed vertical doublet with a randomly located loading coil.

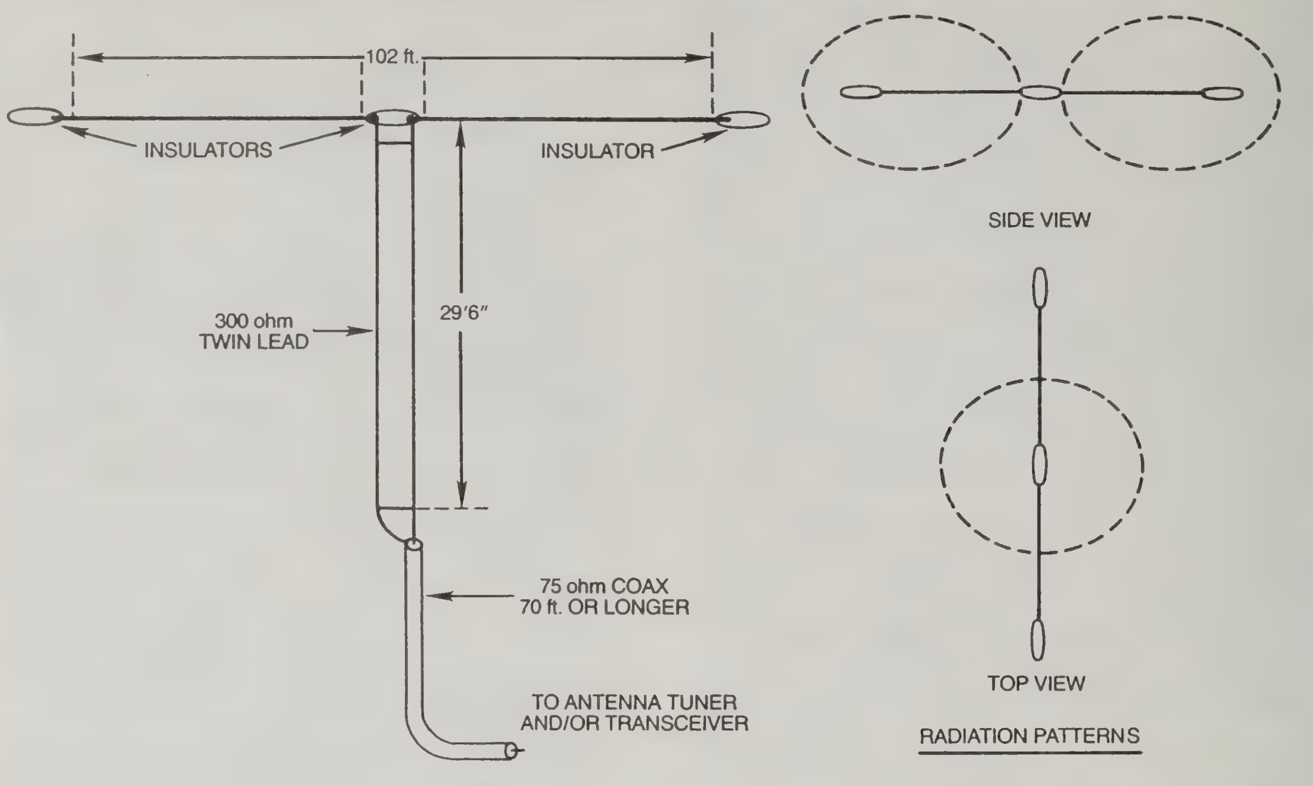
The antenna is tuned for operation on a desired band by experimentally moving the coil's tap then monitoring indoor rig-measured SWR (Please work sequentially or you will get an RF burn and your rig will "see" an open-ended cable during tap movements.). Approximately "4 inches worth of coil" (as measured from the vertical radiator's connection) is usually required for 40 meters, 6 to 8 inches for 80 meters, and 8 to 10 inches for 160 meters. The radiator's full length (and maybe one coil turn) is resonant on 30 meters. Experiment with taps for 20, 15, and 10 meters to create a base loaded ⅝-wavelength "gain" vertical. Alternately, a transmitting grade (wide spaced) 250-pfd variable capacitor can be inserted between the radiator's lower end and the coaxial cable's center connection (alligator clip) to electrically "shorten" the radiator to ¼ wavelength and tune for minimum in-station SWR. A number of shack-to-antenna trips may be necessary before coil points of minimum SWR are determined for all bands. Mark each band's coil tap with fingernail polish to permit rapid band changes later. Finally, we remind you the coil and its alligator connections should be weatherproofed, and we leave that aspect to your personal creativity. Tupperware boxes are good starting points. Properly assembled and maintained, this "overgrown mobile whip" is an impressive, all-band vertical providing surprisingly good results.

THE TRAPLESS G5RV MULTIBAND ANTENNA

The G5RV is a unique and inexpensive antenna that is capable of surprisingly good results on the 80- through 10-meter HF bands, including our 30-meter WARC band on 10.1 mHz. The design is somewhat a cross between the classic Zepp and an open-wire-fed doublet, and is the creation of G5RV in England. This sky wire's attractive points include a slight increase in gain on frequencies above 40 meters, a convenient means for casually enjoying activity on several bands or quickly scanning for DX signals, and the sidestepped use of traps or a deluxe transmatch. Actually, those are very favorable results for such a simple and "low profile" antenna.

Dimensions and layout of the G5RV multiband antenna are shown in **Figure 4–12**. The 102-foot length of wire may be number 12, 14, or 16 for medium power setups, or small gauge hookup wire can be used for QRP pursuits or brief portable operating stints. Bear in mind, however, that small wire is quite susceptible to breaking when stressed between supports and affected by winds. When selecting 300-ohm twin lead, try to use the heavy duty type with larger conductor wires (be sure, however, you do not choose the shielded type twin lead).

There are two minor stipulations and an "experimentally" flexible one regarding the G5RV multiband antenna. Erect the antenna at least 34 feet above ground to allow the twin-lead section to "fall" exactly vertically and end above ground level. Also, use 70 feet or longer lengths of coaxial cable between the twin lead and the station's transceiver to ensure smooth band-to-band tuning. Although 75-ohm coaxial cable is normally used with this antenna, a number of amateurs report



G5RV ANTENNA: 102 ft. overall						
COVERS	80 meters	40 meters	30 meters	20 meters	15 meters	10 meters

Figure 4-12 *The G5RV multi-band antenna.*

switching to 50-ohm cable without any noticeable differences in performance. Either way, we suggest using an inexpensive antenna tuner (the "coaxial cable input/output" type is fine) between the transceiver and antenna for providing a perfect 1:1 SWR on all frequencies. Otherwise, the SWR will probably rise to 2.5:1 or maybe 3:1 on some band edges (although the antenna will continue working properly). Finally, we should mention the G5RV's radiation pattern changes somewhat with the band of operation. This is no cause for alarm, the sky wire's overall radiation and DX capabilities are always good.

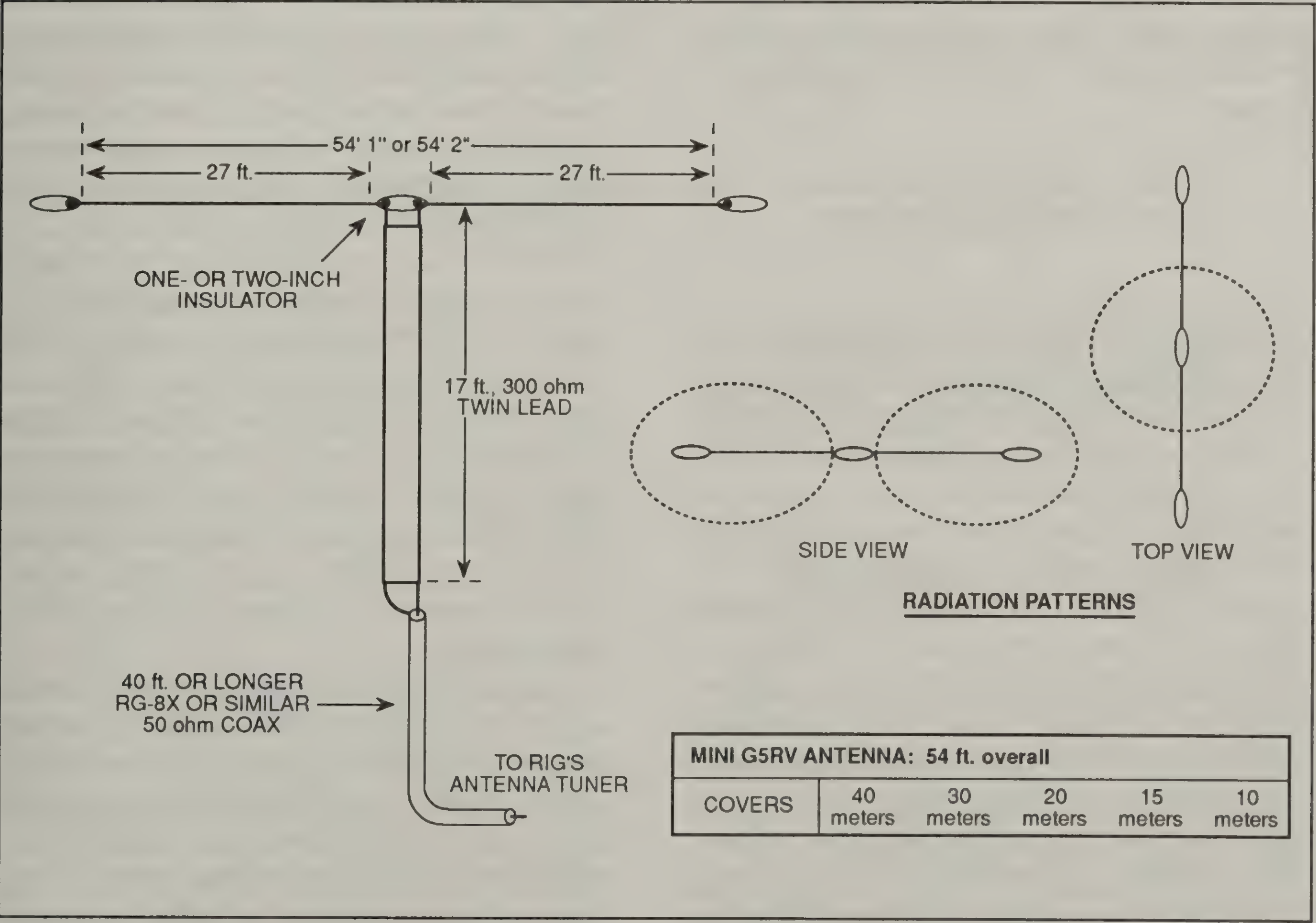
A MINI G5RV MULTIBANDER

Widespread interest in the G5RV antenna recently spawned an approximate half-size equivalent which also works well. This "vest pocket" wire antenna is ideal for amateurs with space limitations, it is easy to assemble, and it works all bands (including WARC) 40 through 10 meters. Several amateurs also report connecting the antenna's in-shack coaxial cable shield and center conductor together, directing that single connection to their tuner's long wire terminal, and working it against a good ground for effective 80-meter operation. Like its "big brother," the half-size G5RV can also be mounted in a horizontal, inverted vee, or sloping configuration to fit your available area. The "mini's" gain on 20 through 10 meters is slightly less than a full-size G5RV, but its performance is usually better than a basic dipole. If your HF transceiver includes an automatic antenna tuner, combining its use with the mini or full-size G5RV can easily spoil you. Simply select a band and frequency, activate the tuner, and enjoy. Radio should always be this simple and enjoyable.

Assembly details for the mini G5RV are included in **Figure 4-13**. The flat top or doublet section consists of two 27-foot "sides" with a one or two inch center insulator. The vertical section is a 17-foot length of high quality 300-ohm twin lead. RG-8X cable, at least 40 feet in length, connects between the twin lead and your station's antenna tuner.

If you plan to use this antenna mainly for portable operations or with a "barefoot" transceiver at home, insulated hookup wire is quite acceptable for the flat top section. Higher power requirements will necessitate using copperweld or equivalent wire. Likewise, select a 300-ohm twin-lead type with large conductors for carrying RF current without overheating. RG-8X cable is suggested here to illustrate your options. This 50-ohm coaxial cable can also be used with the full-size G5RV if desired. The cable is low loss, small and lightweight, and handles up to 500 watts of RF energy.

Some commercial manufacturers of G5RV antennas are including a 1:1 ratio balun at the coax-to-twin-lead connection; however, cor-


54' 1" or 54' 2"
27 ft.
27 ft.
ONE- OR TWO-INCH INSULATOR
17 ft., 300 ohm TWIN LEAD
40 ft. OR LONGER RG-8X OR SIMILAR 50 ohm COAX
TO RIG'S ANTENNA TUNER
SIDE VIEW
TOP VIEW
RADIATION PATTERNS

MINI G5RV ANTENNA: 54 ft. overall					
COVERS	40 meters	30 meters	20 meters	15 meters	10 meters

Figure 4-13 *The mini G5RV multibander. This antenna operates on 40 through 10 meters, and it works great with autmatic antenna tuners found in many modern tranceivers.*

rect balun operation should be studied thoroughly before using it. Many baluns include ferrite cores that become saturated and actually create, rather than eliminate, detrimental effects when subjected to high RF levels. The balun's location on the G5RV or mini G5RV can "fall at" high RF points on several bands, even with only 100 watts to the antenna. Play it safe; select a high power balun and/or balun that eliminates core saturation for use in the G5RVs. The Radio Works Company's baluns have proven to work well in G5RV antennas.

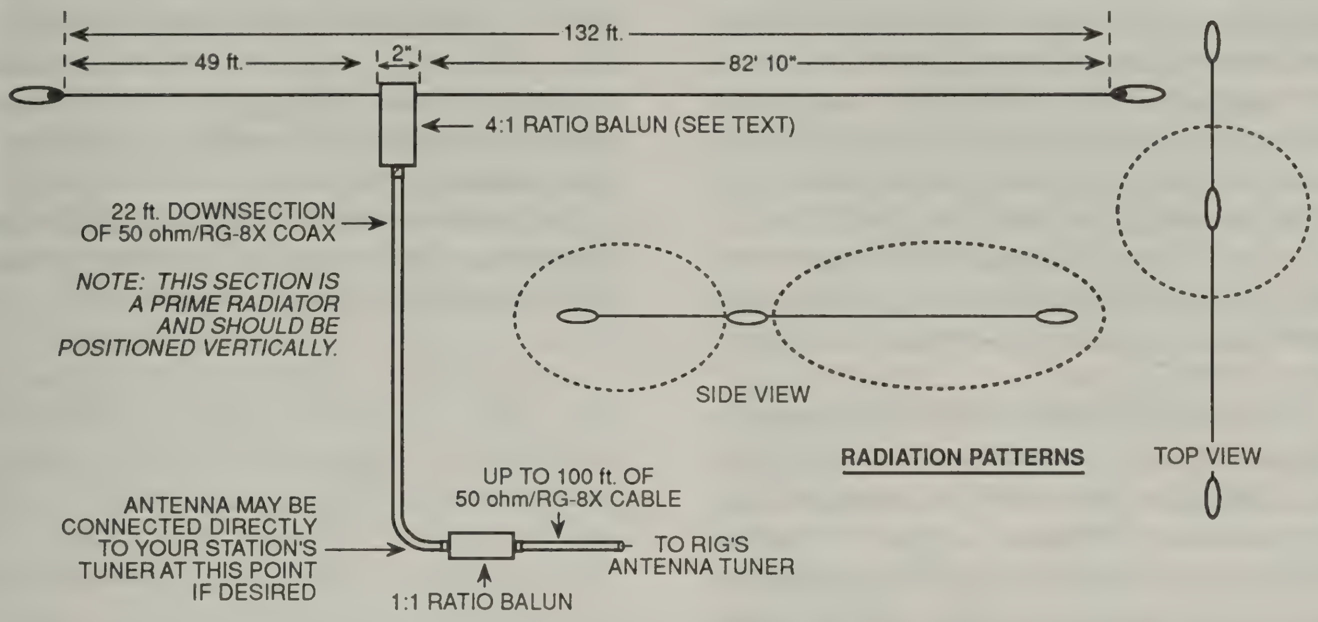
A "micro" version of the G5RV is also possible. Simply reduce the "mini's" dimensions by half to create a 27-foot overall flat-top section and an 8.5 foot twin-lead section, and connect it to at least 21 feet of 50-ohm coaxial cable. The "micro" will cover 20, 18, 15, 12 and 10 meters. Do not mix dimensions such as adding a 17-foot down section to a full-size G5RV, for example. Enjoy the G5RV and its variations. They are impressive performers.

THE CAROLINA WINDOM

While operating on 30 meters during every spare moment of recent months, I noticed the consistently outstanding signal of WY4R. I called to inquire about the operator's antenna. Operator Jim Wilkie explained that his personally designed sky wire worked all bands 80 through 10 meters, including WARC frequencies; and he had named it the Carolina Windom for his home state and Loren G. Windom of 1920 antenna fame. Jim said his city lot was situated such that it supported only one wire antenna, and he desired multi-band activity with reasonable gain. His off-center, coaxial-fed doublet filled that requirement perfectly. Jim switched from the Carolina Windom to a vertical, and the difference was amazing. We could barely copy WY4R while Jim was operating on the vertical. Jim says similar reports on Carolina Windom excellence are common. After one accepts its unusual design and installs the antenna, it works DX beautifully.

The Carolina Windom appears to exhibit several decibels gain over a dipole, especially on upper HF bands. The SWR runs slightly high on some frequencies (although antenna performance is not degraded), so an antenna tuner is required for proper operation (the manual or the automatic types work fine). This antenna can be erected in a horizontal, vee, or sloping position to fit your available supports. It can even be "bent" at the ends if necessary. Further, the antenna's indoor antenna connections can be shorted together and worked against ground for 160-meter operation. At least six ¼-wavelength radials are suggested for that ground system. The Carolina Windom is a good low cost "DX getter" with a proven record of performance. Jim has worked over 50 countries in his spare time in three months with it, and a nearby friend contacted 40 countries on 80 meters during a single weekend using another Carolina Windom. Our special thanks to Jim, WY4R, for sharing his design information with this book's readers. We should also mention the Radio Works Company (P. O. Box 6159, Portsmouth, Virginia 23703) recently negotiated an agreement with Jim to manufacture full Carolina Windom antennas ready to install. Whether you purchase the Radio Works' package or assemble your own version from available spare parts, we are confident you will like the performance of this new antenna

Assembly details for the Carolina Windom are shown in **Figure 4-14**. The top section consists of one 49-foot side and one 82-foot, 10-inch side. Overall length, including the center balun, is 132 feet. A Radio Works or equivalent 4:1 ratio balun that does not become core-saturated is used at the feed point, and a 22-foot down section of 50-ohm RG-8 or RG-8X coaxial cable is connected to the


132 ft.
49 ft.
2"
82' 10"
4:1 RATIO BALUN (SEE TEXT)
22 ft. DOWNSECTION OF 50 ohm/RG-8X COAX
NOTE: THIS SECTION IS A PRIME RADIATOR AND SHOULD BE POSITIONED VERTICALLY.
SIDE VIEW
RADIATION PATTERNS
TOP VIEW
UP TO 100 ft. OF 50 ohm/RG-8X CABLE
ANTENNA MAY BE CONNECTED DIRECTLY TO YOUR STATION'S TUNER AT THIS POINT IF DESIRED
TO RIG'S ANTENNA TUNER
1:1 RATIO BALUN

THE CAROLINA WINDOM: 132 ft. overall						
COVERS	80 meters	40 meters	30 meters	20 meters	15 meters	10 meters

Figure 4-14 *The Carolina Windom. This cleverly designed multibander works 80 through 10 meters and packs a powerful wallop!*

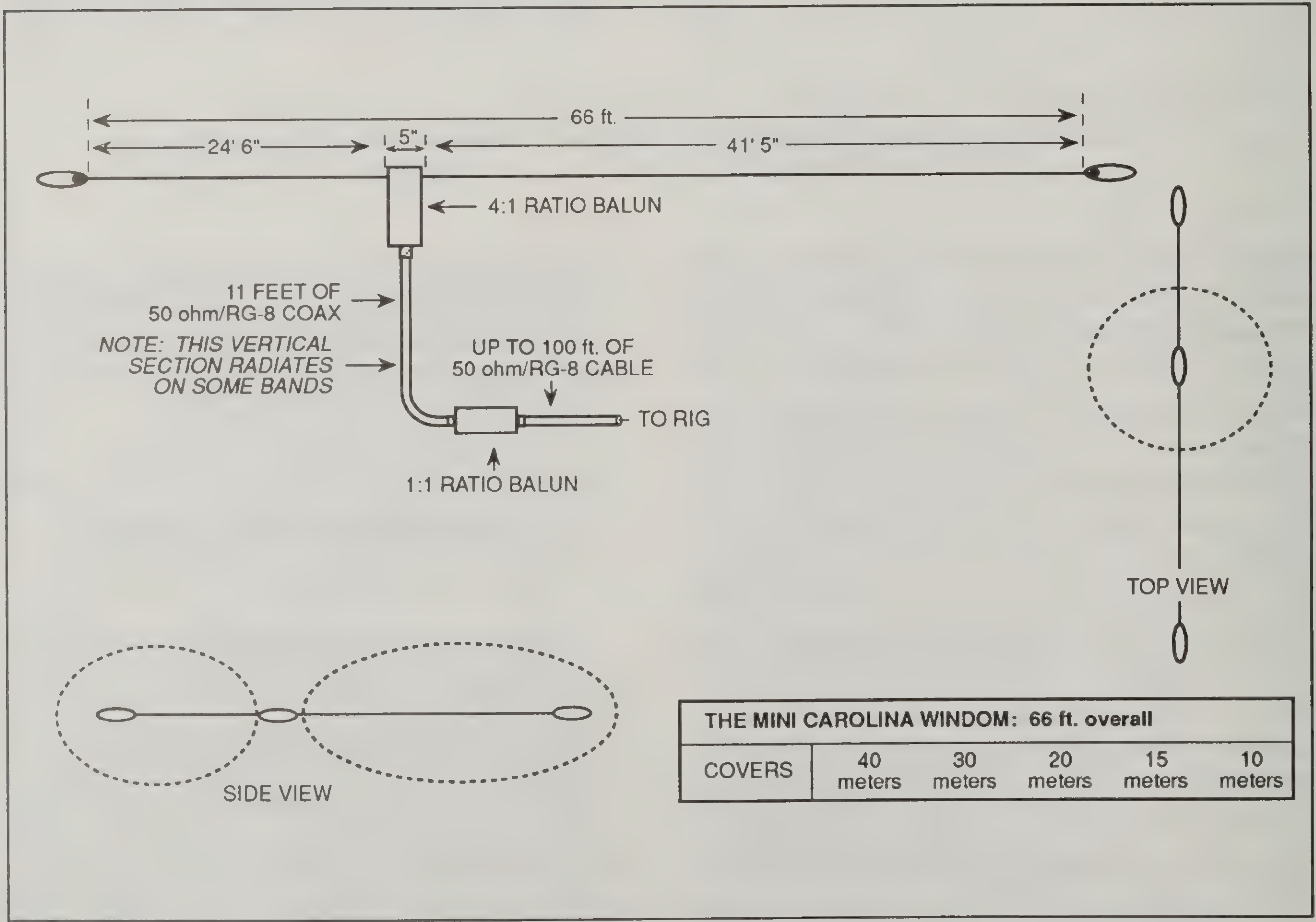
balun. Since that down-lead section comprises part of the antenna's radiation system on various bands, attempt to mount it in a vertical position. If the down-lead's end will reach your rig, it can be connected directly to the antenna tuner's coaxial cable output and operated without additional cable. Otherwise, a 1:1 ratio balun should be installed at that point and any suitable length of 50-ohm RG-8 or RG-8X cable should be added to reach your setup. If the feed point and cable weight are not supported and allowed to dangle freely, use a large gauge wire for the flat-top section to handle the weight. Weatherproof all exposed connections and coaxial cable openings to ensure long-term top performance. Initial reports from Carolina Windom users emphasize that this sky wire outperforms full-size G5RV's. Others say its performance is comparable to a triband beam. Any way you consider it, those are good compliments for such an inexpensive and easy-to-install antenna. The Carolina Windom is a winner.

THE MINI CAROLINA WINDOM

Before initial excitement over WY4R's hot performance Carolina Windom began to settle, Jim was busy testing a half-size version, which also worked well on 40 through 10 meters. Once again the indoor cable connections were shorted, connected to a tuner's long wire terminal, and worked against ground; and again, the extended coverage gave 80-meter operation. The mini version did not exhibit gain comparable to the full-size antenna, but it did not take a back seat to other antennas. Aside from its convenient backyard dimensions, the mini Carolina Windom is a dandy portable or vacation antenna. It can be assembled at home using small coaxial cable and insulated flexible wire, then rolled up and quickly installed at your temporary site. Pruning dimensions are not necessary. Simply connect it to your rig's automatic antenna tuner, power up, and start DXing the bands. What a gem!

Construction information is included in **Figure 4-15**. As you will notice, this is an exact half-size version of "big brother." The only obvious difference is that 1:1 balun, optional on the full-size Carolina Windom, is vital in "little brother." Locating your rig within 11 feet of the antenna's feed point places it in the full-induction field and unnecessarily invites RF feedback. Use two cables and two baluns to avoid RF burns from the key or mike. This mini Windom can be installed horizontally, vee, sloping, or bend. You will need to wind it in knots and bury it to stop it from radiating.

A "micro" version of the Carolina Windom also works 20 through 10 meters. Dimensions are exactly half of a "mini."



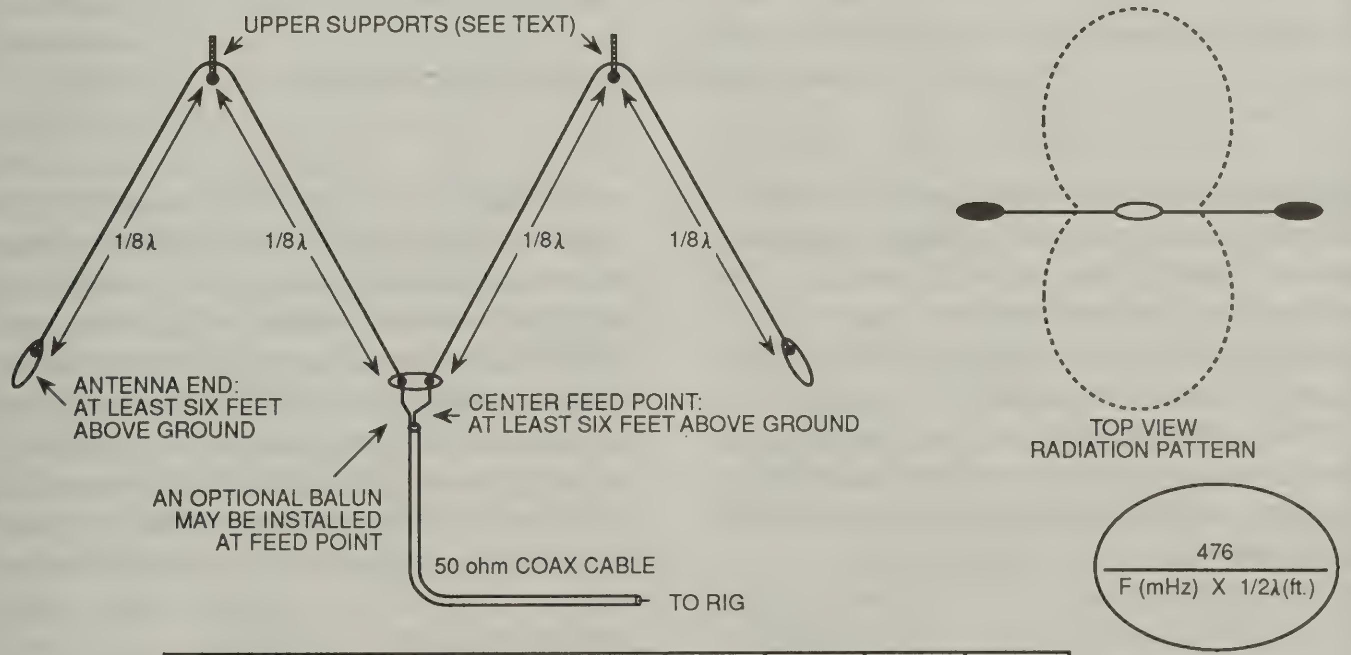
THE MINI CAROLINA WINDOM: 66 ft. overall					
COVERS	40 meters	30 meters	20 meters	15 meters	10 meters

Figure 4-15 *The mini Carolina Windom. This sky wire works like gangbusters on 40 through 10 meters.*

THE DOUBLE INVERTED VEE FOR TIGHT SPACES

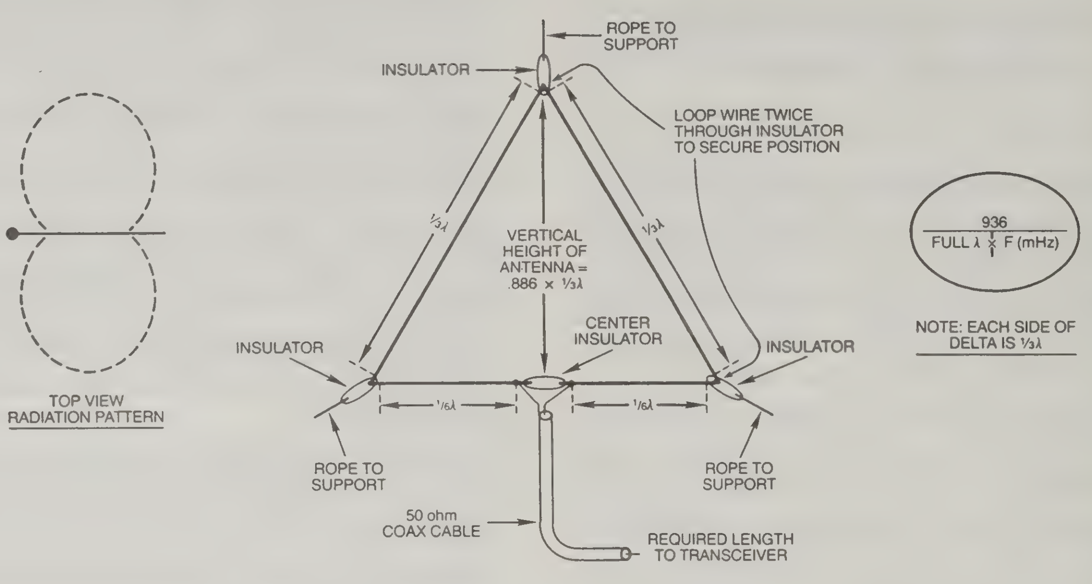
A natural problem associated with many HF antennas for low frequencies is acquiring sufficient horizontal length and/or vertical height when erecting the antenna. Somehow, those two parameters never fit together in the desired manner. If we solve the antenna length problem, the height is too low; and if the height is attained, needed end supports turn up in the middle. The solution? Use a doubled-vee-type dipole (or other wire) supported at the middle of each side with the feed line connected five to six feet above the ground. The antenna's center connections are easy to reach for installation or servicing, and each end is also within an arm's length for frequency pruning. Furthermore, the sloping vee sections on each side produce an appropriate low-radiation angle for DX. Those qualities do not mean the doubled vee performs better than a regular inverted vee; however, it is a clever space saving/utilizing technique for installing a long wire antenna in a small backyard. If this antenna does not fit your need right now, remember its design. It may prove to be your perfect solution one or two years from now.

An outline of the doubled vee's assembly is shown in **Figure 4-16**. The two center supports can be tree branches, house roof corners, or other natural supports slightly less than 1/8 wavelength above ground. Their exact height will determine each side's slope angle which typically falls between 30 and 45


UPPER SUPPORTS (SEE TEXT)
1/8λ
1/8λ
1/8λ
1/8λ
ANTENNA END: AT LEAST SIX FEET ABOVE GROUND
CENTER FEED POINT: AT LEAST SIX FEET ABOVE GROUND
AN OPTIONAL BALUN MAY BE INSTALLED AT FEED POINT
50 ohm COAX CABLE
TO RIG
TOP VIEW RADIATION PATTERN
476
F (mHz) X 1/2λ(ft.)
HALF WAVE FORMULA FOR INVERTED VEE

BAND	160 meters	80 meters	40 meters	30 meters	20 meters	18 meters	15 meters	12 meters	10 meters
FREQUENCY	1.820 mHz	3.750 mHz	7.100 mHz	10.100 mHz	14.100 mHz	18.100 mHz	21.100 mHz	24.900 mHz	28.600 mHz
OVERALL LENGTH (1/2λ)	261.53 ft.	126.53 ft.	67.04 ft.	47,12 ft.	33.75 ft.	26.29 ft.	22.55 ft.	19.11 ft.	16.64 ft.

Figure 4-16 *The doubled vee for tight spaces. The antenna design concept is applicable to dipoles and longwires alike.*


ROPE TO SUPPORT
INSULATOR
LOOP WIRE TWICE THROUGH INSULATOR TO SECURE POSITION
⅓λ
⅓λ
VERTICAL HEIGHT OF ANTENNA = .886 × ⅓λ
936 / FULL λ × F (mHz)
NOTE: EACH SIDE OF DELTA IS ⅓λ
CENTER INSULATOR
INSULATOR
INSULATOR
⅙λ
⅙λ
TOP VIEW RADIATION PATTERN
ROPE TO SUPPORT
ROPE TO SUPPORT
50 ohm COAX CABLE
REQUIRED LENGTH TO TRANSCEIVER

BAND	160M	80M	40M	30M	20M	17M	15M	12M	10M
FREQUENCY	1.820 mHz	3.750 mHz	7.100 mHz	10.100 mHz	14.100 mHz	18.100 mHz	21.100 mHz	24.900 mHz	28.600 mHz
OVERALL ELEMENT LENGTH (Full λ)	514.2 ft.	249.6 ft.	131.8 ft.	92.6 ft.	66.4 ft.	51.7 ft.	44.3 ft.	37.6 ft.	32.7 ft.
HEIGHT OF DELTA	148.4 ft.	72 ft.	38 ft.	26.7 ft.	19.2 ft.	14.9 ft.	12.8 ft.	10.9 ft.	9.4 ft.

Figure 4-17 *Delta loop antenna dimensions and layout for HF bands.*

degrees. Since each side's length is distributed both horizontally and vertically, required space is used to maximum advantage. Simply ensure the antenna's feed points and ends are sufficiently raised to avoid curious young hands and then enjoy the results.

This antenna configuration is suitable for long dipoles, G5RVs, and long wires alike. Use your creative ingenuity in its application and good 160-meter DXing is yours.

THE DELTA LOOP ANTENNA

As most radio amateurs will attest, any antenna's performance in both transmitting and receiving is directly influenced by its overall capture area. Compacted antennas are "compromising" radiators while oversized antennas are more desirable radiators. Bearing that fact in mind, we present details of the delta loop antenna which is a full wavelength of wire configured in a triangle shape and RF-fed with 50-ohm coaxial cable. The attractive points of the delta loop are a low angle of radiation plus good performances even when erected at rather low heights, large signal capture area, and installation using a single high support.

Layout and dimensions of the delta loop antenna are shown in **Figure 4–17**. The wire can be any convenient and reasonably strong material (twice normal length means twice normal weight). As a matter of convenience, we suggest initially "laying out" the antenna on the ground and forming its shape before erecting it. This will allow you to secure a top support/hanger bracket at the apex and one at each side (one end of an insulator works nicely—mark the spot, then tightly loop antenna wire through it twice and hold it securely in place). Next, fasten a long length of rope (previously drawn over your upper support) to the apex's insulator and raise the peak almost into position. You can then draw the corners outward with similar rope/insulator stabilizers and secure them to tie points near the ground. If the delta loop occupies sufficient free space, you may also be able to rotate the loop 90 degrees and take full advantage of its bi-directional pattern which is broadside to the loop. The delta loop's height can be calculated as follows: 0.866 times ⅓ full wavelength of wire. Note: This will be the antenna's maximum vertical size; not its height above ground. The antenna may be RF-fed at the center or at either side of the bottom "leg" as desired with negligible differences in performance.

Creative-minded amateurs might consider adding a director and/or reflector element to produce a high performance wire array for serious low-band DXing. If that idea is pursued, a reflector's length would be five percent longer than a full wavelength and a director's length would be four percent shorter than a full wavelength. Element spacing will be the same as a Yagi parasitic array, and the formula can be translated/scaled as discussed in Chapter Three. Physical connections between RF-driven and parasitic elements will not be necessary with the array.

THE CLASSIC ALL-BAND DOUBLET

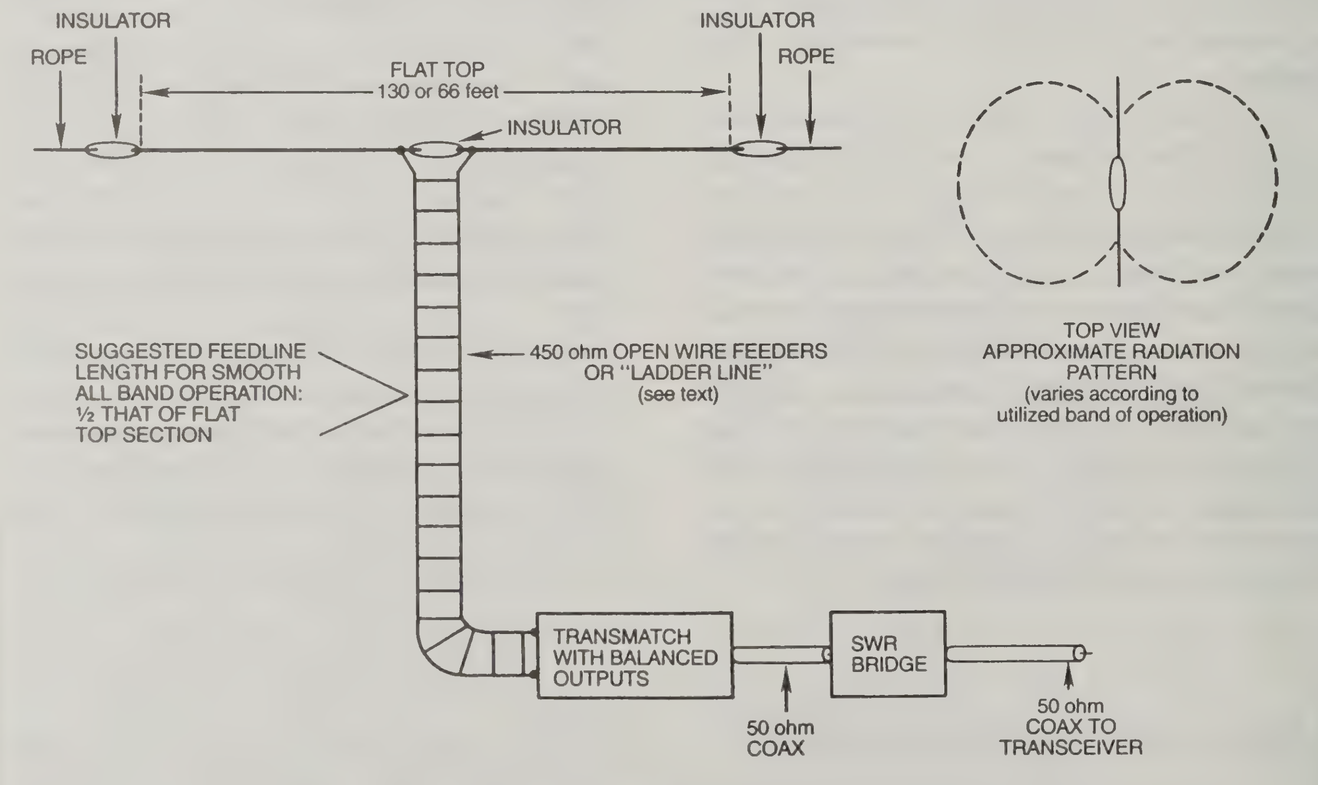
If you have joined our amateur radio world recently, you have probably overheard radio veterans favorably discussing an all-wave antenna which uses open-wire feeders and an indoor transmatch or matchbox. The antenna seems to fit into any space one has available, does not use traps, and employs a very low-loss feed line which works fine regardless of SWR. Does such an antenna actually exist? Yes indeed, and that old time favorite can also be successfully used on our new WARC bands with a modern solid state transceiver. If you are looking for an effective way to operate several HF bands with a single inconspicuous antenna, this might be exactly the sky wire you have been seeking. You will need an antenna tuner with two wire-balanced outputs for RF-feeding the antenna, but today those items are almost as plentiful as mikes or keys.

Dimensions and layout regarding the classic all-band doublet are shown in **Figure 4–18**. The top section is made with ordinary antenna wire, and the feed line is 450-ohm "open line" with plastic spacers or "ladder line." The antenna's usual top length is 130 feet (a first choice which yields good performance on 80 through 10 meters), but many amateurs report favorable results with an overall top length of 66 feet. Actually, any length over one half wave for your lowest operating frequency can be used successfully.

The open-wire feed line can be assembled at home or purchased commercially as desired. Saxton made open line a few years ago, and according to recent advertisements, it is still available. Homemade open line can be made with number 12 or 14 solid wire and wooden spacers of 3 to 5 inches. Place the spacers every 10 to 12 inches and glue them to the feed line for rigidity. Weatherproof each for longevity, and you are set. Two other "feed line wire candidates" are somewhat wider than 300-ohm twin-lead ladder line (it looks like big twin lead with air slots along its length), and heavy duty (not shielded, though) 300-ohm twin lead. The latter is probably a last choice, but it still works well.

As previously mentioned, an antenna tuner with balanced outputs is required for RF feeding this antenna. The "modern difference" between an unbalanced output tuner (for coaxial lines and/or long wires) and a balanced output tuner is an internal bifilar-wound balun and twin binding post on the rear for open line feeders. This is an optional feature on many tuners; as an alternative you can wind your own balun and add it to your basic tuner.

Operation of this classic all-band doublet consists of adjusting its mating tuner for minimum SWR on a desired band. Using only enough RF energy for SWR meter readings, set the tuner for lowest SWR. Increase power, recheck the tuner adjustments, then log dial settings for quick reference later. If this procedure is followed on each band and recorded tuner settings for 1:1 SWR's are placed in direct view from the operating position, changing bands can be accomplished within a very few seconds. This antenna has a proven record as a "stout performer." Try one for yourself the next time you need all band capabilities at low cost.


INSULATOR
ROPE
FLAT TOP
130 or 66 feet
INSULATOR
INSULATOR
ROPE
SUGGESTED FEEDLINE LENGTH FOR SMOOTH ALL BAND OPERATION: ½ THAT OF FLAT TOP SECTION
450 ohm OPEN WIRE FEEDERS OR "LADDER LINE" (see text)
TOP VIEW
APPROXIMATE RADIATION PATTERN
(varies according to utilized band of operation)
TRANSMATCH WITH BALANCED OUTPUTS
50 ohm COAX
SWR BRIDGE
50 ohm COAX TO TRANSCEIVER

CLASSIC ALL BAND DOUBLET: 130 or 66 ft. overall									
COVERS	160M	80M	40M	30M	20M	18M	15M	12M	10M

Figure 4-18 *The classic all-band doublet.*

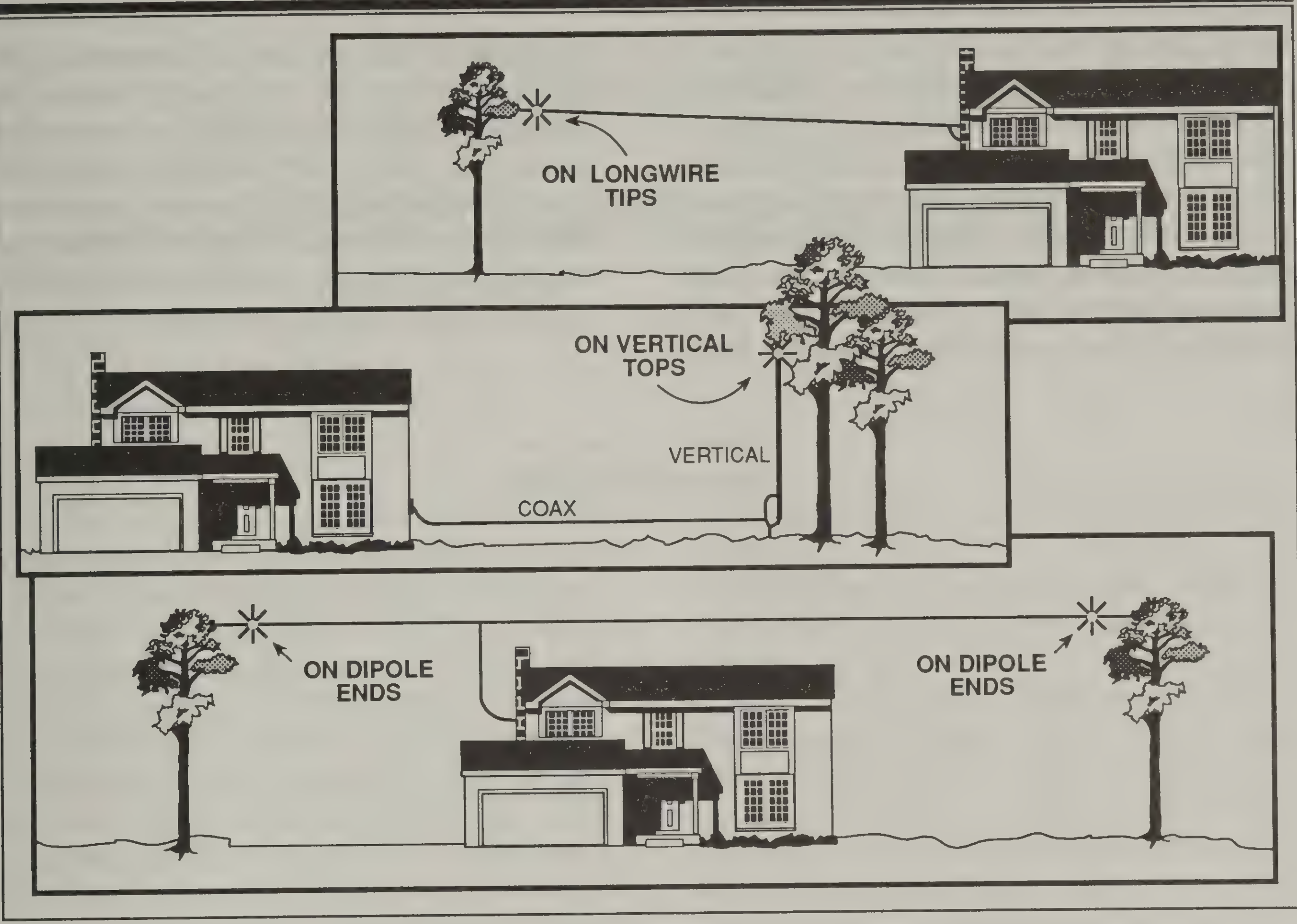


Figure 4-19 *Three examples of winking antennas. Small neon lamps clipped to wire ends are the secret.*

WINKING ANTENNAS

One of the seldom realized aspects of modern technology is its substitution of serious minded progress for genuine, old-time lighthearted fun and glamor. The classic special effect of an antenna that flashes with your transmitted CW, for example, has all but disappeared from amateur radio setups around the country, and many newcomers have never viewed those memorable displays. Needless to say, our compelling drive to rectify that situation inspired this section's contents. There is a heartwarming beauty to looking out your shack's window on a warm summer night and seeing your signals leaving for distant lands. It is a unique form of mental confidence, so to speak, and we are proud to resurrect the winking antenna's details for today's amateurs.

Simply explained, adding one or two small NE-2 or similar neon pilot lamps to a horizontal antenna's ends or a vertical's top creates the winking effect. **See Figure 4-19**. RF energy from your signal ionizes the lamp's gas, causing it to flicker with each CW keydown or SSB voice peak. Because neons are capable of high speed ionization, amateur friends can stand in view of your antenna and visually copy your Morse as it is transmitted—an ultimate "on the air" symbol. Impressive? You bet!

A small neon lamp placed at a peak voltage point on your antenna will not mysteriously absorb RF energy, although it may bring out neighborhood curiosity. Only one of the neon's wires need contact a radiator for ionization at power levels up to 100 watts. If you run at super power levels, simply hanging small neons on nearby metal rails or tower guy wires may also create some interesting displays. During holiday seasons, they can be spray painted with translucent colors and arranged in festive designs. They can even be added to your mobile HF antennas. We also understand an increasing number of presently popular plug-in night lights also use neons, but check them closely before purchasing to make certain that you are getting neon lamps. Use your imagination when arranging your display, then enjoy soft winks in the night while you DX the bands.

ANTENNA NOTES

CHAPTER FIVE

SUPER PERFORMANCE HF ANTENNAS

INTRODUCTION

Ever since the early days of wireless, radio amateurs have pursued the construction and use of high-gain antennas for communicating over long distances. These investigations and resultant evaluations are endless, especially in our present age of widely advertised and noticeably expensive aluminum arrays. Costly radiators are only one approach toward that "big signal" end; however, wire arrays can provide comparable to even better performance at a fraction of the cost and without the neighborhood visual impact of aluminum arrays. This is indeed an area where every amateur's efforts are rewarded tenfold on both transmitting and receiving, and it is also an ideal way to experience a "super system" which otherwise would not be feasible for various reasons. Maybe some practical examples would help clarify the previous thoughts. Both financially restricted newcomers and limited budget retirees can enjoy amateur radio fully by using wire arrays with gain figures equalling those of rotary beams. Although few amateurs would consider setting up a five- or six-element 20-meter aluminum array or a three-element 80-meter antenna at a seldom-used or remote site, a wire array would provide a similar performance and open new doors in communications possibilities. If the array were destroyed or left behind, the overall physical loss would be miniscule compared with a lifetime of memories its outstanding performance provided. There are numerous occasions when wire arrays have their advantages.

As one might logically surmise, there are a few trade-offs when using directional wire arrays instead of aluminum counterparts which may be rotated. Most wire arrays are fixed-position radiators, and wire elements usually exhibit less bandwidth coverage than larger cross-area tubings. These consequences are not serious drawbacks because many amateurs habitually seem able to operate around similar band areas (phone or CW segments) even when daily/nightly openings favor one direction over another (e.g., late night openings toward the South Pacific). What are your favorite operating times and communication areas?

Some amateurs may question if the time spent assembling a super performance wire antenna justifies the effort. A simple dipole or long wire could be assembled and erected in less time. This is true, but why be a small fish in a big sea when you can be a big fish in a big sea. Short operating stints providing big returns have their benefits over long operating stints providing small returns.

The antennas described in this chapter illustrate what can be achieved with minimum finances and a sincere dedication of available time (A pleasant trade-off.). They are fairly easy to assemble and erect (as compared with aluminum equivalents), and they can be expanded as your ingenuity dictates. Once again we will use the common formulas discussed in Chapter Three for scaling dimensions, and we encourage you to review Chapter Two and Three for clarifying ideas on tuning/pruning and feed line matching. Now let us consider exactly what can be accomplished with a bit of patience and a few rolls of antenna wire.

A CURTAIN GOING UP

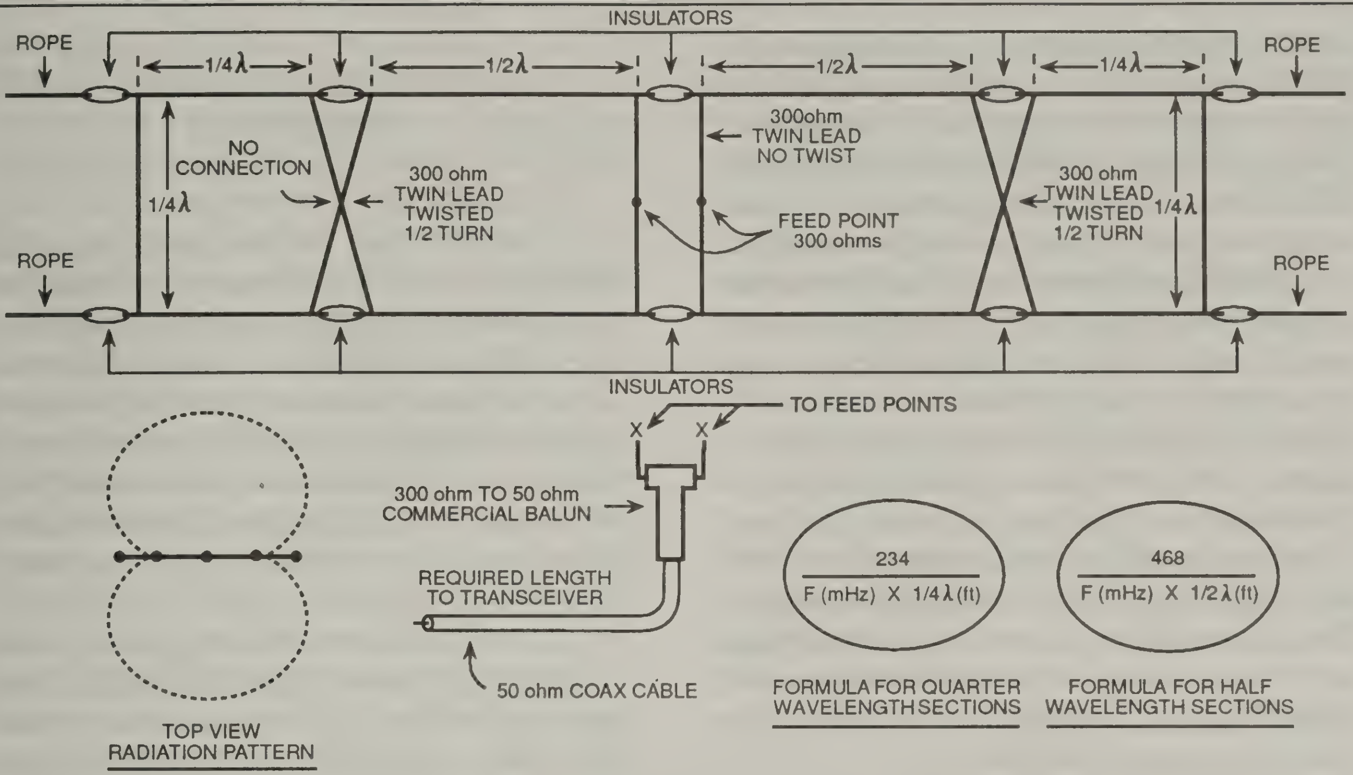
If you are blessed with a reasonable amount of open space and a few favorably placed or available supports, here is a wire antenna which will really give your signal a boost. We call it the mini-Sterba curtain, but many users have nicknamed it "dynamite" because of its commendable performance. Each section or element is constructed of regular antenna wire, with 300-ohm twin lead used as phasing sections between the elements. A popular 300-ohm to 50-ohm commercial balun is used to permit RF feeding of the array using 50-ohm coaxial cable, and several decibels of gain can be measured broadside to the bidirectional array. The curtain's overall dimensions will depend upon its particular band of use: 10-meter arrays are compact while 80- or 160-meter "curtains" become gigantic. Of course, amateurs with yet greater available space and ambition can add an identical, but not RF-fed, reflector of the same dimensions ¼ wavelength behind the driven curtain for an additional three to four decibels of gain and unidirectional performance. This antenna is capable of "full blown" parasitic beam performance at a much smaller cost and visual impact.

Layout and dimensions of the mini-Sterba curtain are shown in **Figure 5–1**. Each radiating section is constructed of regular antenna wire which is separated by insulators and secured in place by "double loops" through insulators or by short twists of extra wires. Heavy duty 300-ohm twin lead is normally used for transposing adjoining sections and providing proper RF phasing. Several amateurs report using wider spaced "ladder line" or homemade four-inch separated spacers here with identical antenna performance. Use whatever style you prefer, but avoid mixing those styles in a single curtain antenna. Notice that each phasing line is twisted a half turn while the center section is not twisted. Also notice that each "outside" section forms a closed loop. The antenna's feed point is midway of the center 300-ohm line, and a 4:1 balun is used for easily matching and balancing the array to 50-ohm cable.

The easiest way to erect this antenna is to suspend it from high tree limbs by ropes connected to "upper insulators." The "bottom insulators" can be secured to lower places on the tree for stability. While this mini-curtain or Bruce-type antenna performs best when erected high above ground, outstanding results are also common when bottom wires are only six to ten feet overhead.

PHASED DIPOLE ARRAY

Looking for an easy way to achieve gain and directivity using basic radiators? Phase a pair of dipoles! On-the-air performance of such arrays is quite impressive, and the design concept can be used with dipoles or verticals as desired. Most radio amateurs try to orient the dipoles in positions favoring desired areas of communication, such as east/west or Europe or Australia. Also, there are many occasions when a similarly oriented dipole can be erected ¼ wavelength's distance from the original dipole. Assuming separate feed lines are used with each of these antennas, an indoor phasing unit can provide direct unidirectional signal selection in either of the "broadside" directions (with


INSULATORS
ROPE
ROPE
1/4λ
1/2λ
1/2λ
1/4λ
NO CONNECTION
1/4λ
300 ohm TWIN LEAD TWISTED 1/2 TURN
300ohm TWIN LEAD NO TWIST
FEED POINT 300 ohms
300 ohm TWIN LEAD TWISTED 1/2 TURN
1/4λ
ROPE
ROPE
INSULATORS
TO FEED POINTS
X
X
300 ohm TO 50 ohm COMMERCIAL BALUN
REQUIRED LENGTH TO TRANSCEIVER
50 ohm COAX CABLE
TOP VIEW RADIATION PATTERN
234 / F (mHz) X 1/4λ(ft)
468 / F (mHz) X 1/2λ(ft)
FORMULA FOR QUARTER WAVELENGTH SECTIONS
FORMULA FOR HALF WAVELENGTH SECTIONS

BAND	160 meters	80 meters	40 meters	30 meters	20 meters	18 meters	15 meters	12 meters	10 meters
FREQUENCY	1.820 mHz	3.750 mHz	7.100 mHz	10.100 mHz	14.100 mHz	18.100 mHz	21.100 mHz	24.900 mHz	28.600 mHz
QUARTER WAVE	128.57 ft.	62.41 ft.	32.95 ft.	23.16 ft.	16.59 ft.	12.92 ft.	11.09 ft.	9.39 ft.	8.18 ft.
HALF WAVE	257.14 ft,	124.82 ft.	65.91 ft.	46.33 ft.	33.19 ft.	25.85 ft.	22.18 ft.	18.79 ft.	16.36 ft.

Figure 5-1 *Mini-Sterba Curtain layout and dimensions for HF bands.*

several decibels of gain in the process). Arrays of this nature are inexpensively constructed, and they have the potential of increasing the range of DX ability, especially on lower frequency HF bands where rotary beams are difficult to handle.

The outline and dimensions for a phased dipole array capable of several decibels of forward gain is shown in **Figure 5–2**. The antenna's radiation pattern is essentially cardioid (heart shaped). Each dipole is RF-fed by equal lengths of RG8/u or RG58/u 50-ohm coaxial cable, while a quarter-wave phasing/delay section is inserted in one "leg" to achieve directivity. Notice the indoor phasing and tee connected coaxial switching arrangement always connects one dipole directly to the transceiver while the other dipole is RF-fed through the phasing section (a non-shorting coaxial switch is used). The dipole electrically closest to the transceiver is the array's "front," while the dipole connected through the phasing line is the array's "rear."

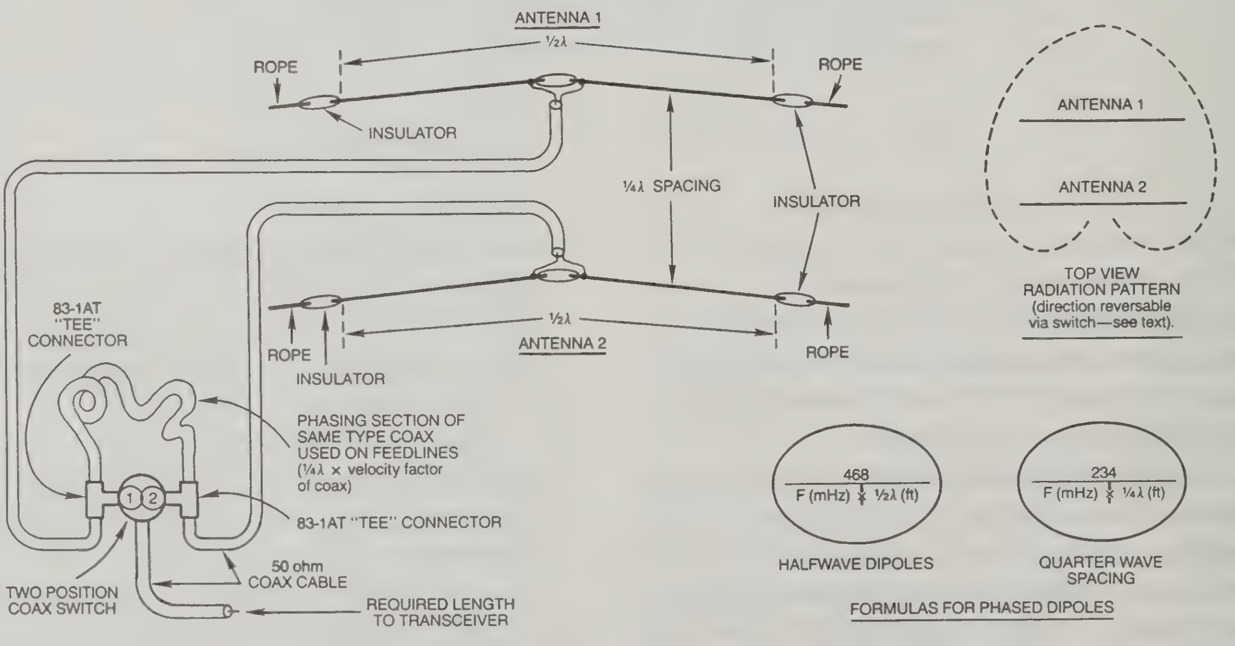
Assembly of this array begins by cutting two dipoles exactly the same length for the desired frequency. Next, use exactly the same line (preferably from the same manufacturer's roll) and cut two equal lengths for transmission lines "running into the shack." A third length of that same coaxial cable is also cut for phasing/delay line. Its length is very important and is determined by multiplying that particular coaxial cable's velocity factor times ¼ wavelength for the desired operating frequency. Following installation, each dipole is checked and tuned to resonance at the desired operating frequency. Both dipoles, plus the phasing section, are then connected to the coaxial switch using PL259s and 83-1AT "TEE" connectors. Double check the overall SWR, weatherproof all exposed outdoor connections, and the array is ready for action.

This phased antenna concept can be successfully employed with various basic radiators of both horizontal and vertical categories, and provides unlimited possibilities for home experimentation. In the latter case, all coaxial lines adhere to previously outlined dimensions while the "substitute radiator" merely connects to the coaxial end which RF-fed the dipoles. While overall performance of the phased dipole array is extremely good, we are not stating exorbitant claims but only suggesting you try one for yourself and experience the superb results.

THE K4TWJ INVERTED WIRE BEAM

Author's note: *A few years ago I assembled a high performance "fold-up" antenna which could be used for portable or vacation operating stints. Later, I found that same antenna design was ideal for radiating an impressive signal on our new 30-meter band. A third version was also scaled for 2-meter operation, and it also performed admirably. I would like to share that general design with you at this time.*

This two-element wire array can be erected using a single center support, and it provides several decibels of gain in its forward direction while using angled elements to conserve



BAND	160 meters	80 meters	40 meters	30 meters	20 meters	18 meters	15 meters	12 meters	10 meters
FREQUENCY	1.820 mHz	3.750 mHz	7.100 mHz	10.100 mHz	14.100 mHz	18.100 mHz	21.100 mHz	24.900 mHz	28.600 mHz
DIPOLE LENGTH	257.14 ft.	124.82 ft.	65.91 ft.	46.33 ft.	33.19 ft.	25.85 ft.	22.18 ft.	18.79 ft.	16.36 ft.
DIPOLE SPACING	128.6 ft.	62.40 ft.	32.95 ft.	23.16 ft.	16.59 ft.	12.9 ft.	11.09 ft.	9.39 ft.	8.18 ft.

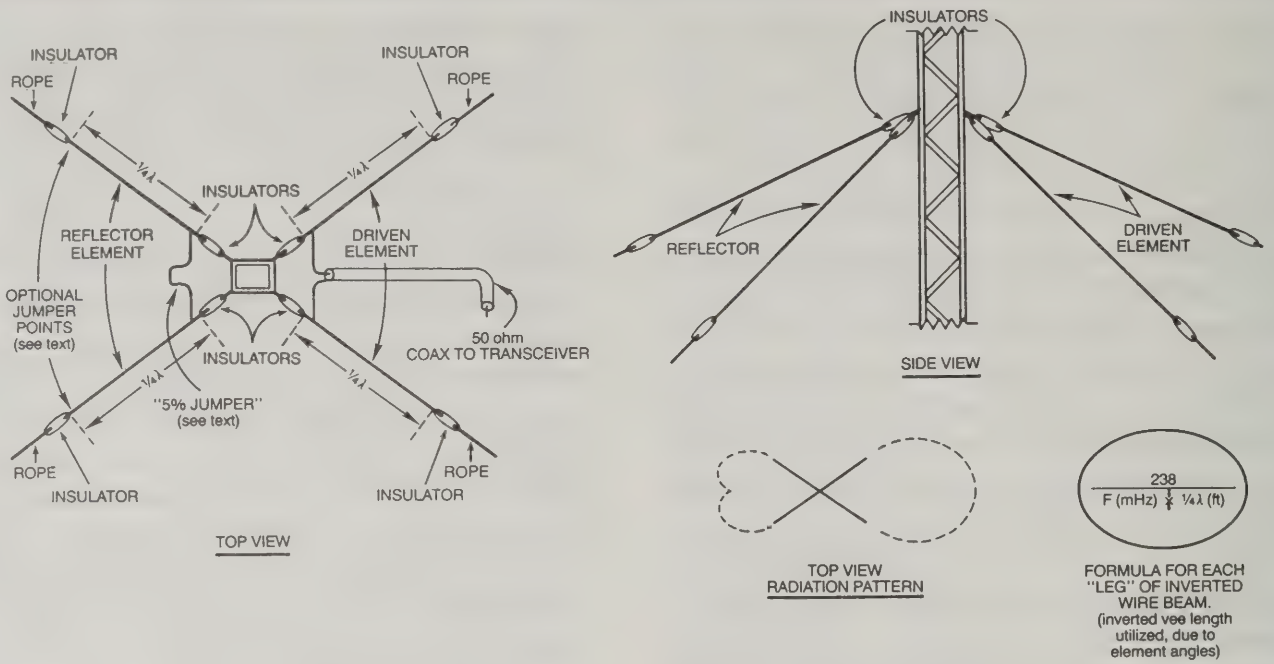
Figure 5-2 *Phased dipole array for HF operation.*

space and achieve a low angle of radiation. The antenna's overall dimensions can be scaled for nearly any amateur band, and favorable results can be enjoyed even when the array is mounted at low heights. Its directivity can be switched in 90-degree increments either manually by feed-point clip leads and jumpers, or a customized switching arrangement can be devised. The general concept of this antenna involves using two inverted vees which are arranged in a pyramid fashion with their ends resembling an imaginary pyramid's base at the four points near the ground and the center sections converging at the pyramid's peak. This positions the wires' main radiation areas at the highest points while placing ends near the ground for easy pruning and length adjusting when changing directivity. The "forward" wires also exhibit a slight vee-beam effect; that gain offsetting the slight loss caused by the continuously varying spacing along driven and parasitic element lengths. That parasitic element may be a reflector or director as desired; however, optimum performance will be realized when using a reflector.

Layout and dimensions of the K4TWJ inverted wire beam are included in **Figure 5–3**. The two inverted vees are first cut for frequency and assembled, then they are installed on the center support. If you presently use a tower with its high band beam, that structure makes an ideal center support for this lower frequency wire beam. Alternatively, you can "lasso" a choice tree limb and drop a tow rope for the center support. Assuming a couple of boards are nailed together and secured to that rope, you will have an "X" frame to which each of the four wires can be affixed/stabilized and that "peak point" can be lowered for swapping connections and changing directivity. While good results can be obtained by connecting the 50-ohm feed line directly to the driven element, I strongly suggest using one of today's popular baluns for optimum performance. All four wires should have insulators at both ends, and "upper ends" should be within two or three inches **of** each other to permit each connection of feed line/balun ends and (parasitic element) jumpers. The antenna's directivity is achieved by using any adjacent pair of wires for "driven elements" and the other wire pair for the "parasitic element." Assuming the latter is a reflector, it should be five percent longer overall than the driven element. Adding length can be accomplished in either of two ways: near-ground end jumpers or a long jumper between upper parasitic element sections. I prefer the latter because a jumper of any length is necessary there regardless, and it confines the "full five percent extra length" to one central point.

As previously mentioned, signal directivity is accomplished by moving element feed points (selecting driven/reflector elements). The easiest way of doing this involves using large alligator clips on balun ends. This arrangement is highly susceptible to corrosion unless protected from the weather, so seal those areas in a plastic box or other form of weatherproofing.

I have always found this antenna to be a compact, yet excellent performer. I enjoy using it in many ways. Incidentally, my two-meter version is constructed with stiff wire supported on a wooden tomato stake. The "bottom areas" of each wire are also folded back toward the stake to create a sturdy setup which resembles a half open umbrella without a cover. Of course, the whole arrangement could be folded back out again to resemble a tiny "bat wing" beam. As highlighted earlier, antenna design expansion is a boundless frontier of personal expression.



BAND	160 meters	80 meters	40 meters	30 meters	20 meters	18 meters	15 meters	12 meters	10 meters
FREQUENCY	1.820 mHz	3.750 mHz	7.100 mHz	1.100 mHz	14.100 mHz	18.100 mHz	21.100 mHz	24.900 mHz	28.600 mHz
QUARTER WAVE	130.77 ft.	63.47 ft.	33.52 ft.	23.56 ft.	16.88 ft.	13.15 ft.	11.28 ft.	9.56 ft.	8.32 ft.
"5% JUMPER" LENGTH	13.00 ft.	6.34 ft.	3.36 ft.	2.36 ft.	1.69 ft.	1.32 ft.	1.13 ft.	.96 ft.	.83 ft.

Figure 5-3 *Inverted wire beam layout and dimensions for HF bands.*

TEE TOPPER DOUBLE TAKE

Attention radio amateurs, the innocent looking sky wire discussed here actually has two faces—and the second one sports a proven "track record" of working Egypt and the Mid-East on 160 meters via long path. While the antenna can be assembled for any HF band from 10 through 160 meters, the true beauty of its design and the benefits of its operation are most noticeable on the lower frequencies. Our first view of this classic flat-top Tee shows a single wire radiator "worked" against ground. See **Figure 5-4**. The combination of vertical and horizontal wire lengths should equal ¼ wavelength for your desired operating frequency. Since this is basically a top-loaded vertical design with a wire top hat, try to make the horizontal wire's length approximately ⅓ the total desired (¼ wave) dimension and the vertical wire's length ⅔ the remaining desired length. Likewise, select your Tee's supports so its coaxial feed point is within a few inches of terra firma and use a good ground system, especially if you are a serious 160-meter DXer. Notice that the flat-top section can be supported between two trees, permitting the vertical section to drop down into a clear view of the sky and an effective radiating position. Frequency pruning may be accomplished at either flat-top end or at the vertical wire's lower end. The antenna is simple and effective.

Take a second long (and in perspective) look at **Figure 5-4**. Does it remind you of a tall tower supporting a big 20-meter beam? Topgun, honor roll DXers shunt feed their huge 60- to 120-foot outdoor antennas for big-time 80- or 160-meter DXing. You can assemble your own comparable performance, big-time DXing "vertical with top hat" from wire. The horizontal section simulates a large beam and the vertical section simulates a tower. Since you can insulate it from ground, a shunt feed system is not necessary. Make no mistake about this antenna's performance on 80 or 160 meters. Its full-size dimensions and tall height outworks short, commercial multi-band verticals pressed into "top band" use by a country mile. This full-size 80- or 160-meter antenna will radiate better than it receives, so you will need a very low noise, uniquely designed antenna to compliment it for reception. Our following Beverage wire antenna is an ideal companion. Welcome to the world of top band DXing.

HEAR BETTER WITH A BEVERAGE

Serious low band DXers realize the key to copying signals from faraway lands involves reducing various background noise levels associated with 160- and 80-meter frequencies. Once that cloaking veil is removed, only

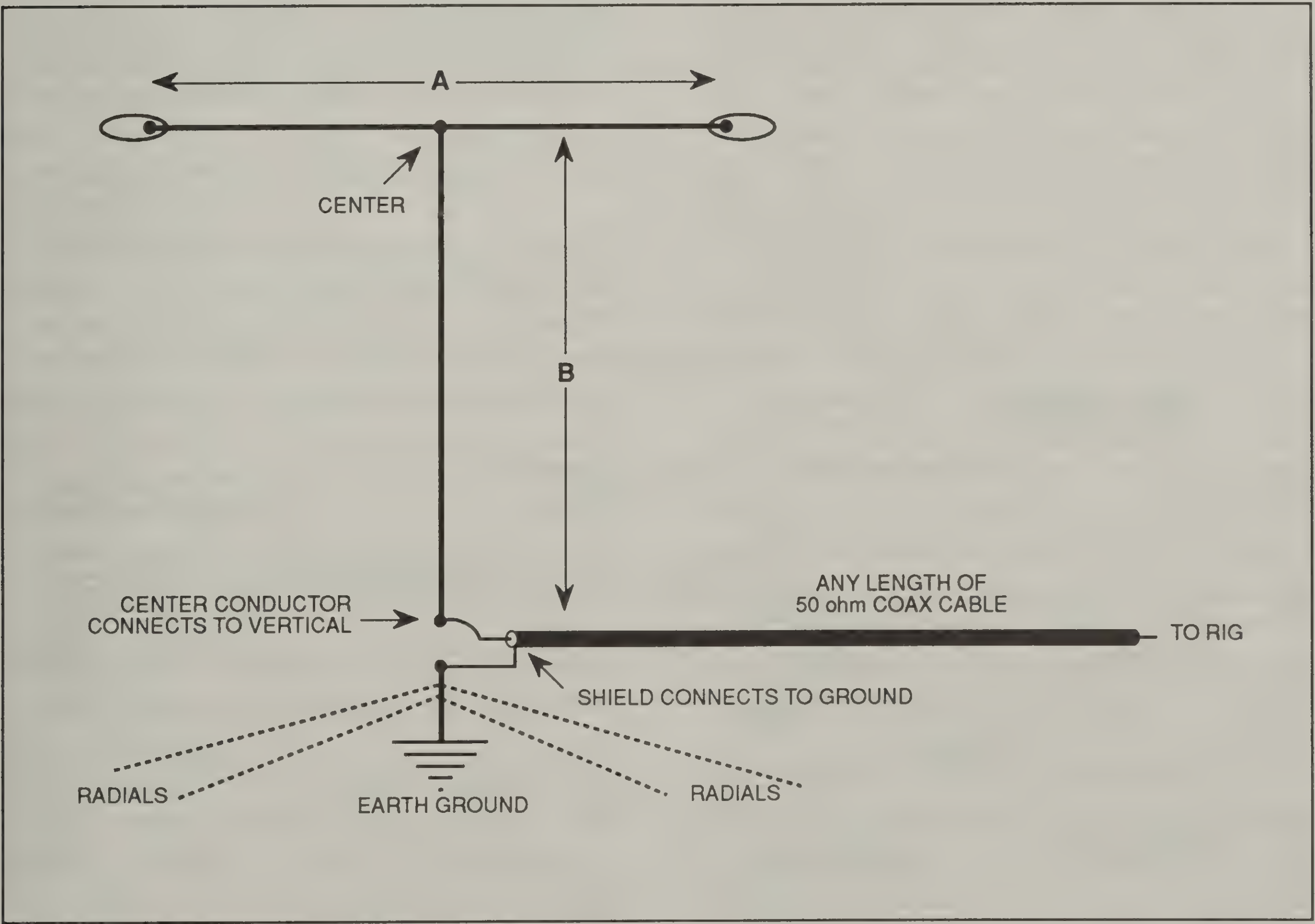

A
CENTER
B
CENTER CONDUCTOR CONNECTS TO VERTICAL
ANY LENGTH OF 50 ohm COAX CABLE
TO RIG
SHIELD CONNECTS TO GROUND
RADIALS
EARTH GROUND
RADIALS

Figure 5-4 *The Tee topper double take. This simple design is a real DX go-getter for low frequency bands. The length of the horizontal section (A) and the vertical section (B) should equal one-fourth wavelength with (B) comprising two-thirds of that length (See text).*

favorable propagation and good operating techniques (plus a couple hundred watts of efficiently radiated power) are required for globe-spanning communications. The supporting basics of those statements are reflected in usual low band characteristics: Summer noise levels block all except close-in DX signals, while quiet wintertime situations permit more weak and truly distant signals to peep above background noises. Consistently copying those signals demands a wire that "hides" from noise and responds to sky-reflected signals.

The Beverage antenna shown in **Figure 5-5** is a proven top performer in this area. It consists of a single 2- to 4-wavelength wire placed directly on the ground (or not mounted over two feet above ground) and impedance-matched to your transceiver's rear panel receiver input. This connection, which bypasses a transceiver's T/R switch section and permits the use of independent receive and transmit antennas, is included on most modern transceivers. The only stipulations in its use are protecting the receiver's sensitive input from strong RF levels and matching impedances for proper signal input.

The Beverage antenna is impedance matched to your receiver by a broadband, 1 to 9 ratio transformer. This item can be constructed as follows: First, wind a primary of approximately 10 turns of number 18 or 20 enamel-coated wire around a 2- or 3-inch toroid. Spread the windings symmetrically

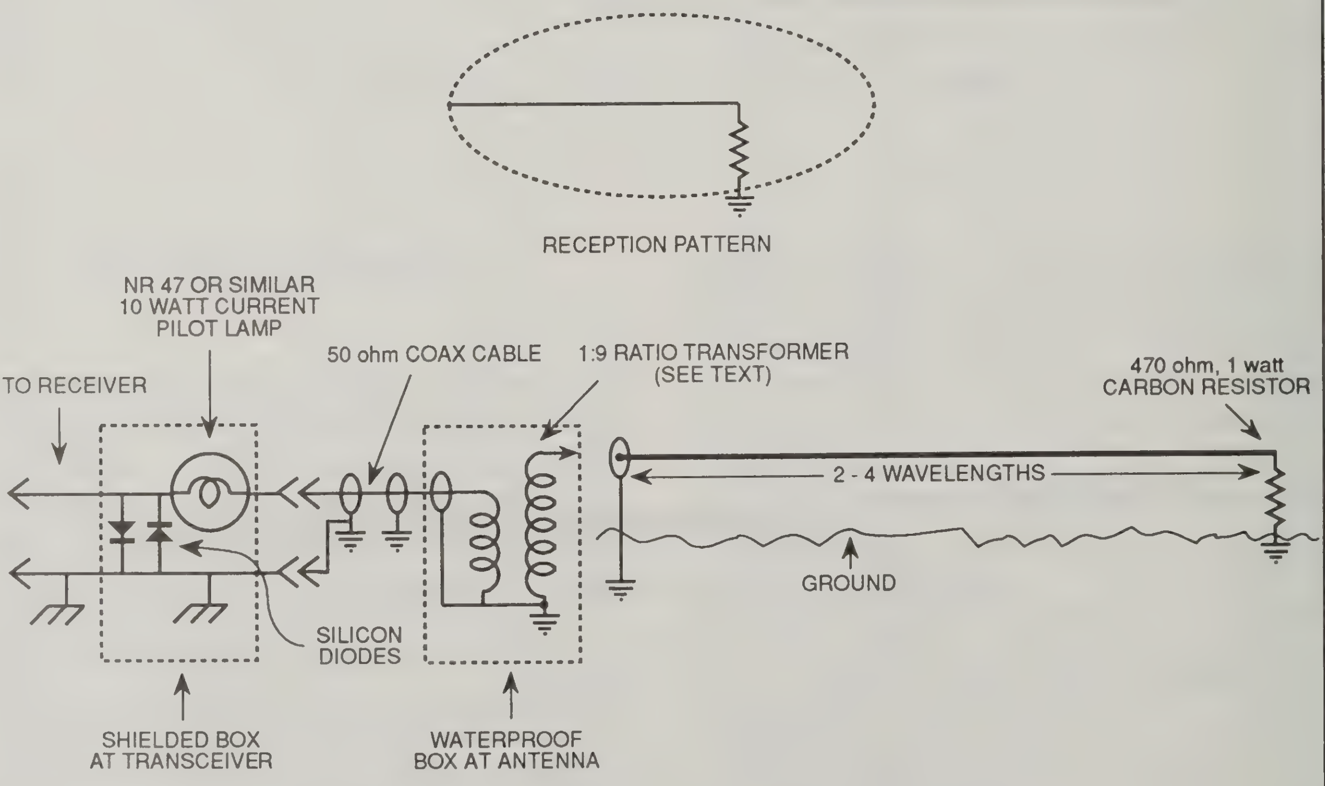


Figure 5-5 *Hear better with this Beverage. This low noise receiver antenna mounts right on the ground.*

around the core, then wrap it with a layer of tape for insulation. Finally, wind a secondary of 90 turns over the primary. Weatherproof the matching transformer and its connections, then add a 470-ohm carbon resistor between the Beverage wire's "far end" and ground.

The completed antenna's resonant frequency and impedance match can be checked by carefully directing only one watt of RF power to the antenna for making SWR measurements. After that step, add the diode and pilot lamp protection circuit and connect the Beverage to your receiver's input.

This 470-ohm terminated Beverage is directional off its "far" (terminated) end with minor pickup lobes off its sides. The "back-to-back" silicone diodes function as a 0.7-volt receiver input limiter, while the small pilot lamp limits input current. An RF preamplifier was normally used with Beverage antennas during past decades, but it is often unnecessary today. Many modern transceivers feature built-in low noise preamps and very high gain "front ends."

Although the Beverage antenna is mainly known for its exceptionally low noise performance on 160 and 80 meters, an increasing number of amateurs located in noisy metropolitan areas continue hailing its benefits on 40, 30, and 20 meters. I personally use a simple one-wavelength Beverage laid directly on the ground under my house for 30- and 20-meter reception, and the results are fabulous. Many times, for example, S-9 power line noises blanket 20-meter reception with my triband beam but drop to zero and permit great DXing with the Beverage antenna. When line noises block Sunday AMSAT Net reception on 14.282 mHz, I switch to the Beverage and it is armchair copy. I can even hear band fades. Honestly! Using the Beverage antenna with an old-time receiver (no noise blanker) and 10-watt transmitter on 30 meters, I have also worked stations from Australia to England off the Beverage's front and back. The surprising point is that my Beverage's mating unit was thrown together in haste and never tuned!

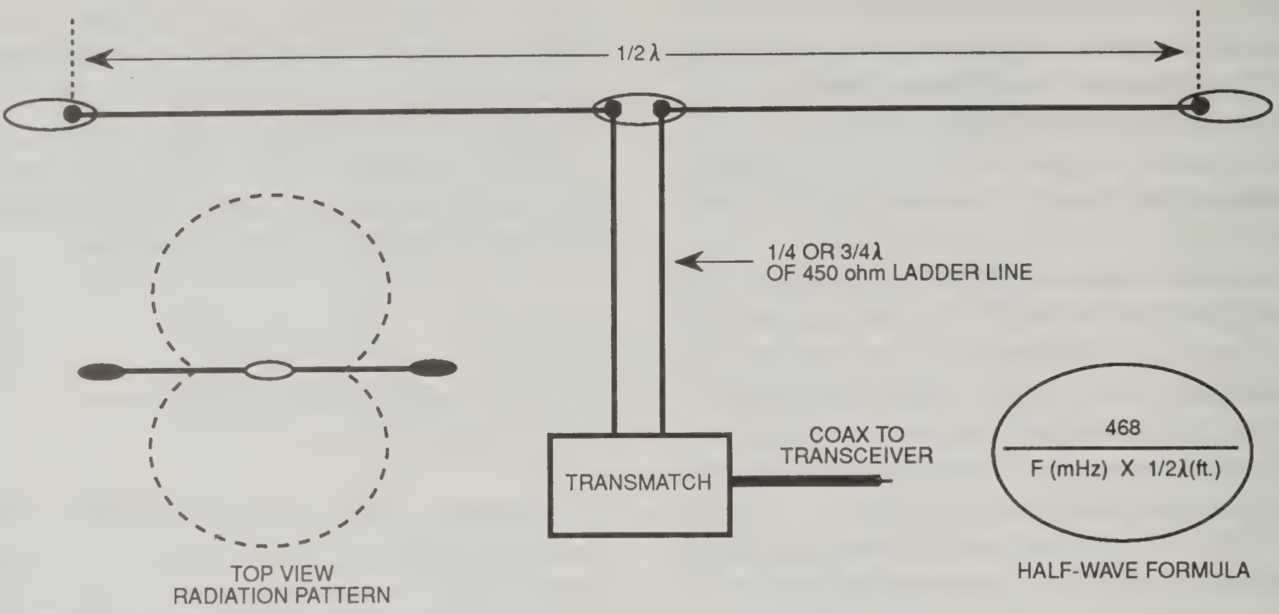
If you are living in a noise-prone area and looking for a good receiving antenna, check out the Beverage. It is inexpensive, easy to conceal, and it is one sharp performer.

ZEE ZUPER ZEPPS

A large number of old-time amateurs fondly recall using Zepp-type antennas for many years, but these impressive performance sky wires are often overlooked by many newly licensed brethren. Realizing the deficiencies of leading such a sheltered life, we now "bring'em back alive" in all their glory for your sophisticated, modern perusal. Look them over and notice their clean simplicity and exclusion of loss-prone coaxial cables. Better yet, install a Zepp Zepp here or Zepp Zepp there at your own QTH and enjoy multi-band operation with low losses. We can not guarantee you will still pick up that big band music and DX calls of yesteryear, but we are confident you will "get out" in high style.

An outline of the basic Zepplin is illustrated in **Figure 5-6**. The horizontal top section is ½ wavelength for your preferred lowest band of operation, with an insulator at the center. The vertical "feeders" are 450- or 600-ohm "ladder line" of ¼ or ¾ wavelength for your preferred lowest band of operation. Specifying that length is necessary because the feeders radiate RF energy just like the top section, and one half or one full wavelength feeders bring voltage peaks into the shack. That often causes mike burns and "hot" keys.

A balanced output transmatch must be used with any Zepp-type antenna to mate its approximate 450 ohm impedance with your 50-ohm output transceiver. Fortunately, however, Zepps operate harmonically related fre-



BAND	160 meters	80 meters	40 meters	30 meters	20 meters	18 meters	15 meters	12 meters	10 meters
FREQUENCY	1.820 mHz	3.750 mHz	7.100 mHz	10.100 mHz	14.100 mHz	18.100 mHz	21.100 mHz	24.900 mHz	28.600 mHz
OVERALL LENGTH (1/2λ)	257.14 ft.	124.82 ft.	65.91 ft.	46.33 ft.	33.19 ft.	28.85 ft.	22.18 ft.	18.79 ft.	16.36 ft.

Figure 5-6 *The classic Zepplin antenna. This multiband sky wire utilizes a balanced-output transmatch and works great.*

quencies and make good multi-band antennas. A transmatch, per se, differs from a "balanced output" tuner in its use of a center-linked, open-air coil for true balanced output. Many modern tuners convert their (essentially) unbalanced output to balanced output using a toroid coil. Additionally, many toroid-equipped tuners exhibit core saturation and heating that creates RF losses. Old-style Johnson "Matchboxes" and homemade transmatches described by Lew McCoy in 1950 to 1960 QST magazines work well with Zepp antennas.

The always popular extended double Zepp with a modern modification for 50-ohm coaxial feed is illustrated in **Figure 5-7**. The horizontal top section's length is calculated using the formula 600 ÷ Frequency (MHz) = length in feet (Example: 600 ÷ 7.000 = 85 feet, 8 inches per side). The vertical feeders length is similarly calculated using the formula: 103 ÷ Frequency (MHz) = length in feet (Example: 103 ÷ 7.000 = 14 feet, 8 inches to balun connection). A 4:1 ratio balun is used at that point, then any required length of 50-ohm RG-8 coaxial cable is employed between the balun and a simple unbalanced antenna tuner at the indoor station. This antenna exhibits approximately three decibels gain over a (reference) dipole at its fundamental (lowest) operating frequency. Since it also operates on harmonically related upper bands, its gain is also prominent on those frequencies.

Both the classic and the extended double Zepp can be installed horizontally, sloping, Vee'd or folded at their ends to fit your available space. In fact, many Zepp lovers encourage Vee configurations to reduce feed-point impedance and provide an optimum match. These antennas have been in use for many years and have been modified, perfected, and improved by many amateurs.

Variations are numerous, and the exclusion of a special or favorite detail here or there should not be taken personally. Amateur radio is intended as a fun hobby for all to enjoy.

Another quite popular classic antenna is the end-fed Zepp shown in **Figure 5-8**. This slim gem has been strung between garage corners and backyard trees of homes across the land for many decades and with good reason. It radiates an impressive signal, and its end feed point drops right into the garage for setups located in those areas. Of course, if you really want to enjoy an end-fed Zepp in high style, install a matching 1940's- or 1950's-type station in the garage. A properly restored Halliscratchers Sky Buddy receiver, Harvey Wails transmitter, and homemade tuner are an absolute blast to use on today's bands. Tube rigs light up, they are warm and friendly, they do not cringe at slight SWR's, and they "get out" beautifully. Fancy and deluxe-featured solid state transceivers are fine for heavily carpeted, in-home "main setups," but they do not compare with authentic rigs from our spirited past set up in a garage or basement. That is sheer nostalgic bliss at its golden best.

The end-fed Zepp's horizontal top section is ½ wavelength for your desired lowest band of operation. One of the tuned feeders connects to the long wire, and the other feeder connects to an approximate 2-inch wire insu-

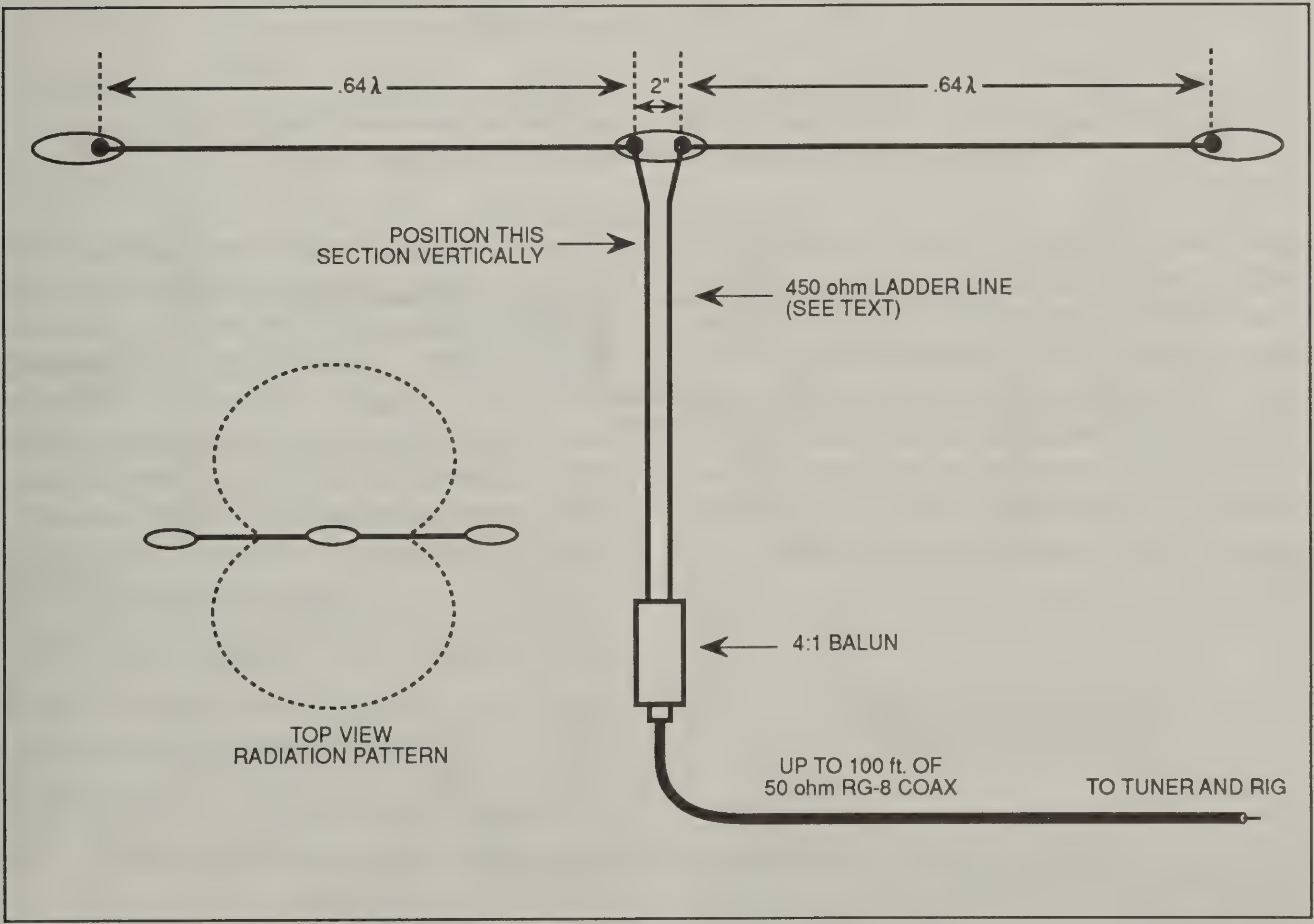

.64 λ
2"
.64 λ
POSITION THIS SECTION VERTICALLY
450 ohm LADDER LINE (SEE TEXT)
4:1 BALUN
TOP VIEW RADIATION PATTERN
UP TO 100 ft. OF 50 ohm RG-8 COAX
TO TUNER AND RIG

Figure 5-7 *The always popular extended double Zepp. We included a modern modification for 50-ohm coaxial feed to mate with unbalanced tuners. The antenna exhibits up to three decibels of gain.*

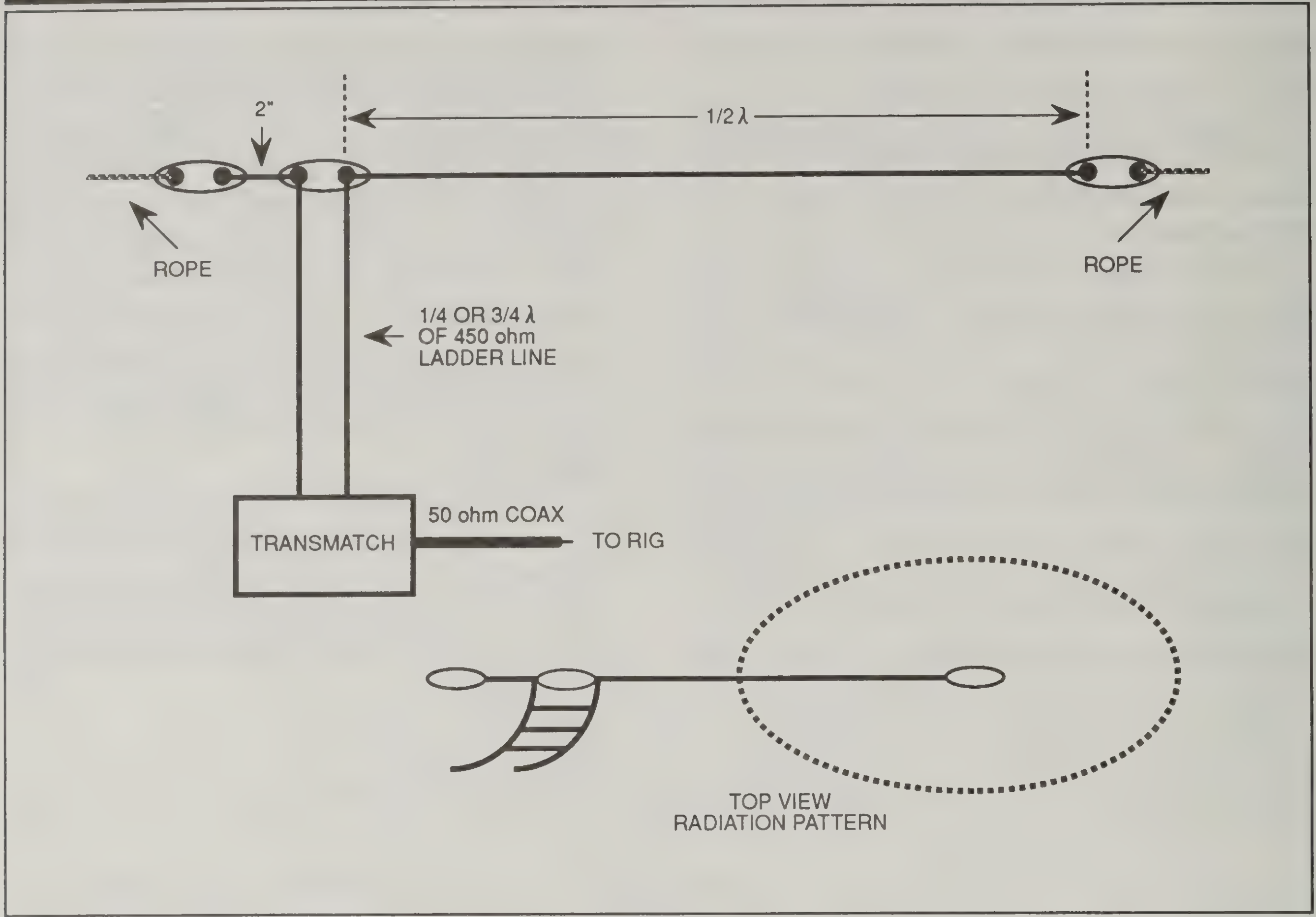


Figure 5-8 *The end-fed Zepp. A classic radiator that works like a champ!*

lated from the garage or other support. The feeders length should be ¼ or ¾ wavelength to avoid RF voltage peaks in the shack. Since a transmatch is used with this antenna, tune-up is also a snap. Simply set the tuner for minimum, rig-measured SWR and start DXing. A bit of "visual confidence" may also prove mentally encouraging, so the following memory from times of old is suggested.

PHASED VERTICALS: A DXER'S DELIGHT!

If your DXing interests are hampered by budget restrictions and/or a desire to keep one foot on the ground during antenna erections, don't feel discouraged, just read on. Phased verticals exhibit reasonable gain and directivity, they produce globe-spanning low radiation angles, and they can be assembled from wire very economically. The following technique is equally applicable to wire or aluminum tubing styles of single-band verticals or ground planes. Further, two tall trees with appropriate spacing can even be used to support a full-sized phased wire vertical array for 80 meters or sloped verticals for 160 meters. Simply use a bow and arrow to place each vertical's "pull-up rope" over top tree limbs. You can get this antenna "up and running" in less than a day. Be forewarned, however, many new phased vertical owners have been found asleep over their rigs with empty stomachs and full log sheets. This antenna gets out great!

Basic details of the phased vertical array are shown in **Figure 5-9**. Each ¼ wavelength radiator consists of a single heavy wire or four wires arranged in a one to two-inch circle with small sections of plastic tubing used as separators. The four wires are shorted together at the top and bottom ends, thus electrically simulating aluminum tubing and broadening the radiator's bandwidth. The radiators are spaced ½ wavelength apart, and an effective ground system consisting of at least 12 one-quarter wavelength radials are installed at each radiator's base area. At least three radials in each ground system should also interconnect to ensure maximum efficiency.

The key to this array's gain and directivity lies in the way each radiator is fed with RF energy. Notice the coaxial Tee connector and extra ½ wavelength of coaxial cable. When both antennas are fed by equal lengths of 50-ohm cable (measured from the Tee junction), an approximate 3 decibels of gain is realized broadside to the array. When an additional ½ wavelength of 50-ohm cable is inserted in either antenna's feed line, the pattern shifts 90 degrees and approximately 3 decibels of gain is realized in-line with the array (see illustration in **Figure 5-9**).

All cables should be the same type (e.g., RG-213), and preferably cut from the same "master spool" to ensure identical aging and velocity. Cables between each vertical and the center Tee can also be longer than ¼ wavelength if desired, just remember to keep their lengths identical. The pattern shifting or phasing section's length is calculated by multiplying your specific cable's velocity factor times ½ wavelength. Example: Technical

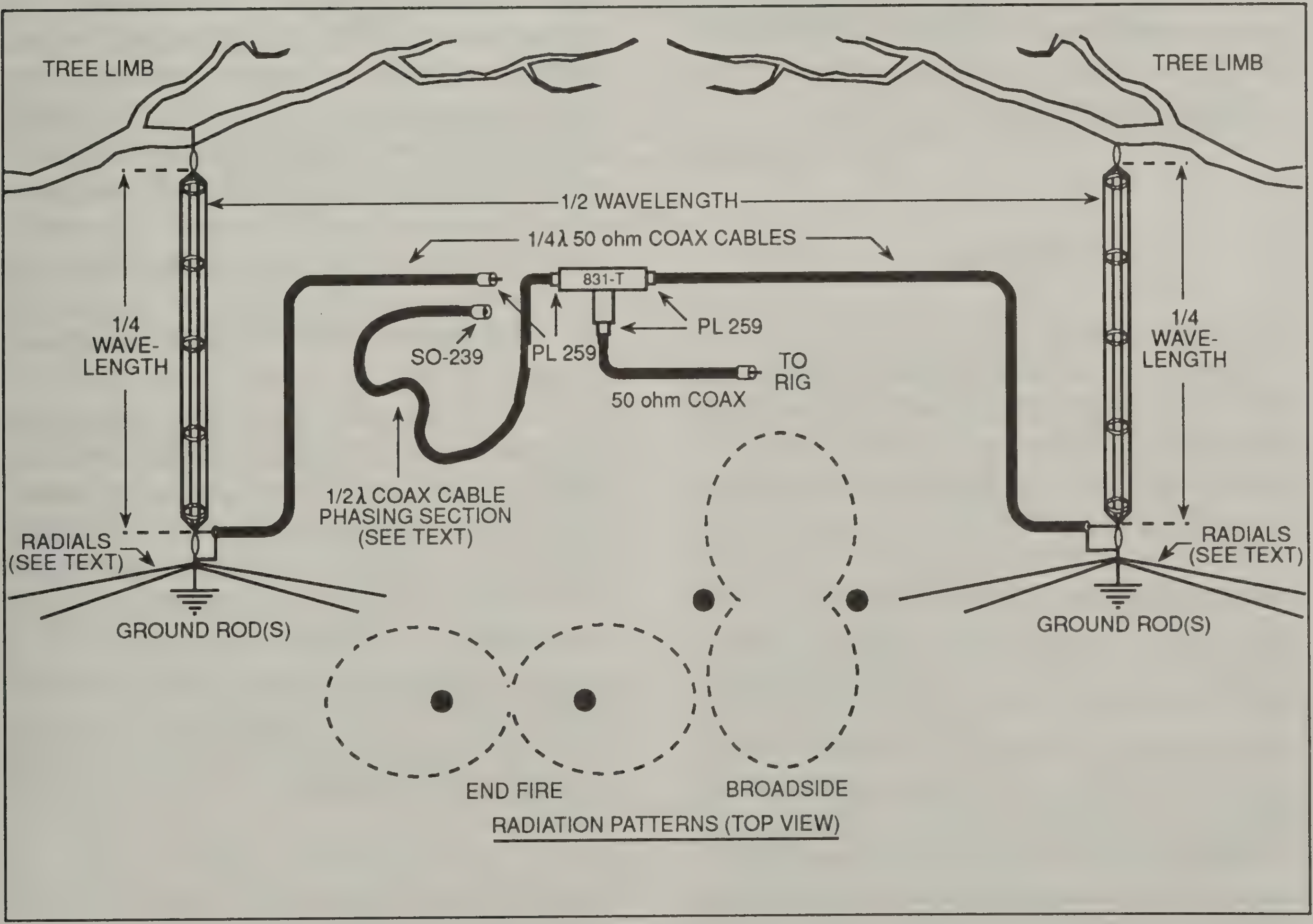


Figure 5-9 *The phased vertical array: A DXer's delight.*

specifications indicate RG-213's velocity factor is 0.66, thus ½ wavelength of phase-shifting cable for 80 meters is 128 (ft) X 0.66, or 84 feet 7 inches. Spread out that cable in a wide single loop or zigzag style; do not coil it up like an RF choke.

While the easiest and simplest way to switch this array's pattern is exchanging connections at the outdoor Tee, many amateurs prefer constructing a remote controlled relay. The choice is yours, and we also leave its weatherproofing techniques to your personal creativity.

Looking at the flat top "tee topper" antenna described elsewhere in this book and applying our phased vertical concepts can really get your adrenaline pumping, especially if you plan to erect two towers with multiband beams in the future for all-out contesting. Think about that. Two gamma rod-matched/shunt-fed towers spaced 260 feet apart can be phased for powerful 160-meter DXing. Say, aren't you thinking about moving to the suburbs next year?

THE 8JK

Here is an all time favorite sky wire and classic antenna surrounded by numerous legends of unquestionable success: the genuine 8JK flat top. Designed by John Kraus during the golden 30's, this wire beam continues to enjoy a prominent place in antenna books and studies almost a half decade later. That is an impressive "track record" by any standard. The 8JK can be assembled for operation on any HF band, but somehow it always ends up being built for 40 meters. Maybe the ghosts of our nostalgic past unconsciously influence our preferences. Whatever the cause or motivation, we invite you to try an 8JK antenna yourself. The results are always favorable.

Construction details of the (40 meter) 8JK are shown in **Figure 5-10**. The radiating sections essentially consist of two dipoles spaced roughly ⅛ wavelength apart and RF-fed by 450-ohm "ladder line". The phasing line between (dipole) sections is twisted ½ turn, or inverted, for proper phasing. Another section of 450-ohm line drops down from the antenna's "front" dipole and connects to a 4:1 ratio balun, then any required length of 50-ohm cable routes to your indoor rig (a modern modification for coaxial cable lovers). Notice the whole antenna is installed on a horizontal plane while the (21 foot) feed line section drops vertically from the front dipole. Notice, also, this antenna features close spacing between elements (nice for small yards), yet give up to four decibels of forward gain.

Several readers are probably asking how the 8JK can be configured for bands other than 40 meters, so here are the details. The dipoles are "standard ½ wavelengths," so use the formula: 468/frequency (mHz) = length (in feet). Example: 468/14.0 = 33.4 ft. A "magic number" for the phasing section is determined by multiplying its original frequency times its original length. Example: 7.0 mHz X 16 ft. = 112. Next, use that "magic number" for your desired band. Example: 112/14.0 = 8 feet. The new feed-line length is calculated similarly: 7 mHz X 21 feet = 147, thus 147/14.0 = 10.5 feet. Simple, eh? This technique of converting any unusual dimensions to other bands, incidentally, works with all sky wires, and it is the perfect way to dimension older antennas to our new WARC bands. If you have a small backyard and want an impressive signal, try the 8JK. It is a gem, and it always creates interest when you mention its use during on-the-air operations—sort of like driving a restored classic car when others are driving regular sedans.

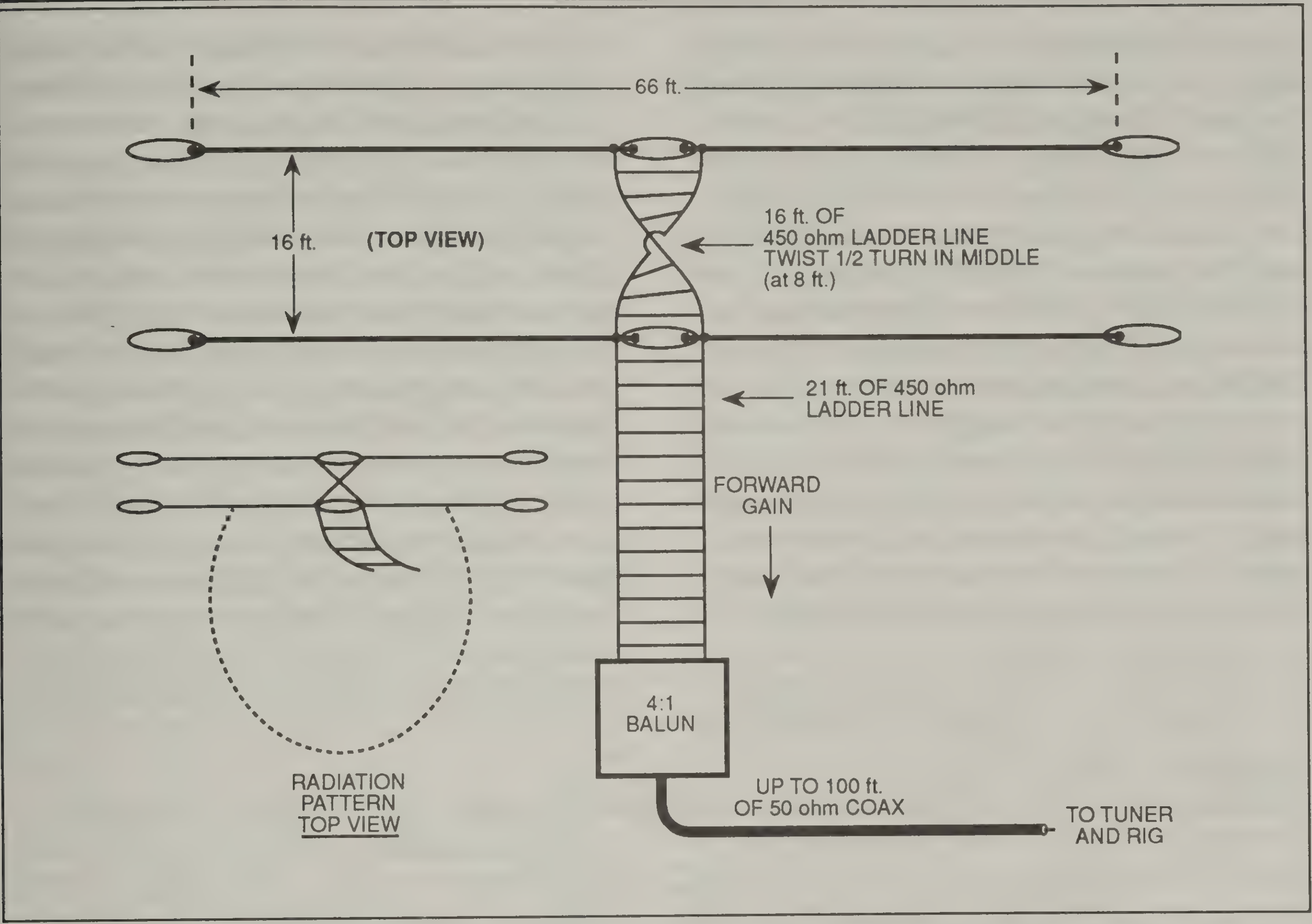


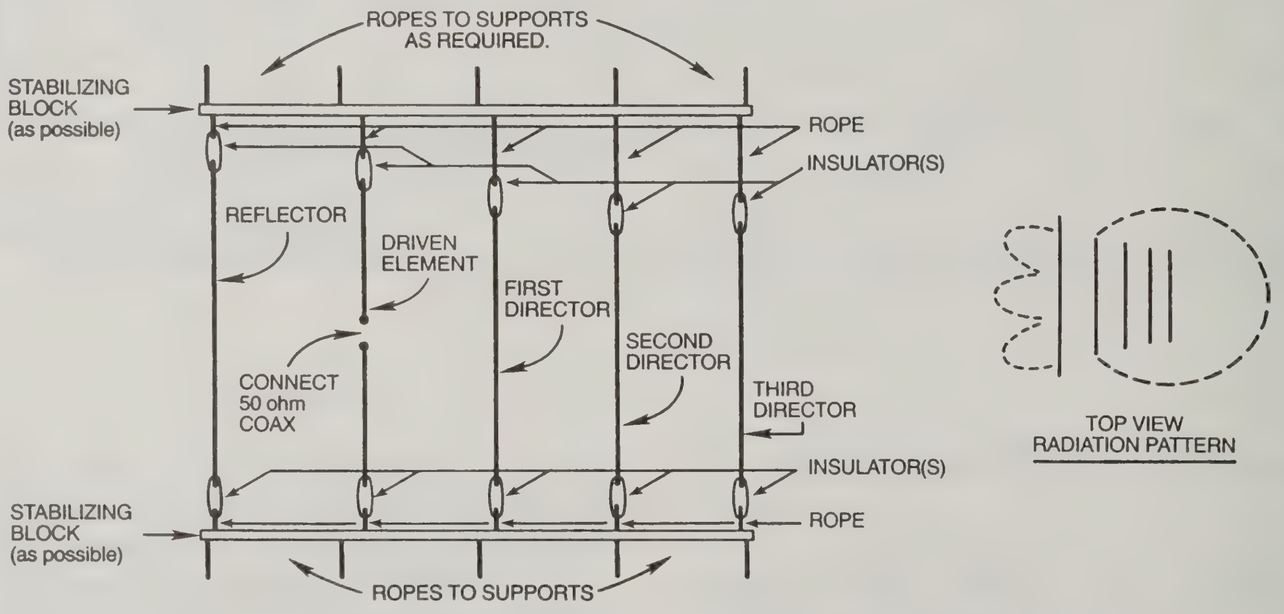
Figure 5-10 *The classic 8JK beam antenna. The array exhibits up to four decibels of gain. The dimensions shown are for 40 meters. Information for scaling to other bands is included in the text.*

AN EXPANDABLE WIRE YAGI

Nearly every devoted radio amateur dreams of someday enjoying "big gun" DXing with a multi-element beam and one of today's deluxe transceivers. Such visions are often clouded, however, when the substantial cost of a fancy indoor setup leaves inadequate funds available for a super performance antenna system. Do not become prematurely disillusioned though; almost anything is possible with a bit of creativity and ingenuity.

The following antenna idea utilizes a flexible design which can be varied to fit your available space and desired band of operation. It can be assembled as a two-, three-, four-, or five-element beam (or larger!) according to the availability of wire and real estate. Because the array can be scaled for 10 or 160 meters (if you own half a county), we have included directly usable formulas for all parameters. The antenna is essentially a basic Yagi using a time-proven design and wide spacing for highest possible performance. It has the drawback of being a "fixed position" antenna, but it also has the benefit of superb forward gain plus high front-to-back and front-to-side ratios. If you have ever wanted to assemble your own "band opening" sky wire for 10, 20, 40, or even 80 meters without investing a fortune in aluminum or towers, here is your chance. Dimensions and layout for the expandable wire Yagi are included in **Figure 5–11**. Typical of this classic design, the reflector element is approximately five percent longer than the driven element, and the director is approximately four percent shorter than the driven element (slight variations, including the driven element's length are the result of "element loading" in this parasitic array). Additional directors are four percent shorter than previous elements, with that figure changing to "same length" after two directors (assuming you have the available area). Spacing between directors can be reduced up to ten percent if our listed "wide space" values are too large for your area. Actually, you could experience that much fluctuation with winds and swaying trees.

If you are fortunate enough to find "natural" element supports such as trees or house corners in usable places, great! Otherwise, common element end ties will be required and a "hammock swing" arrangement can be devised. Begin construction by planning your layout according to the desired communications direction and available supports. Assemble each element separately, double checking lengths and spacing, then hoist the antenna into position using end halyards for later pruning or lowering during stormy weather. Because parasitic elements function through induction coupling, electrical (boom type) connections between elements are not necessary. We do strongly suggest a



REFLECTOR LENGTH (FEET) = $\frac{501}{F\ (mHz)}$

DRIVEN ELEMENT LENGTH (FEET) = $\frac{475}{F\ (mHz)}$

REFLECTOR TO D.E. SPACING (FEET) = $\frac{120}{F\ (mHz)}$

FIRST DIRECTOR LENGTH (FEET) = $\frac{450}{F\ (mHz)}$

FIRST DIRECTOR TO D.E. SPACING (FEET) = $\frac{177}{F\ (mHz)}$

ADDITIONAL DIRECTOR(S) LENGTH (FEET) = $\frac{437}{F\ (mHz)}$

ADDITIONAL DIRECTOR(S) TO PREVIOUS DIRECTOR SPACING (FEET) = $\frac{183}{F\ (mHz)}$

NOTE: Formulas consider loading effects of parasetic elements.

Figure 5-11 *Layout and dimensioning formulas for an expandable wire Yagi.*

center balun, however, on the driven element. After the antenna is connected to the station's transceiver by 50-ohm coaxial cable, check SWR and resonant frequency and prune the driven element length as necessary (Every antenna is influenced differently by its surroundings and height. This fact is especially true here because one may assemble a 40-meter, two-element version or a 15-meter, five-element version, etc.). Beyond this point, you are on your own to enjoy, tweak, prune, and squeeze every additional fraction of a decibel by monitoring forward field strength and varying parasitic element lengths accordingly. We only emphasize that "happiness is knowing when to stop experimenting and start enjoying." That statement applies equally to home-constructed quads, Yagis, dipoles, or any other "in reach" antenna.

Is there serious logic in erecting a colossal beam antenna favoring one single direction? We will answer that query with some actual examples. A few years ago several unrelated amateurs purchased extremely high powered amplifiers or large antennas for only one purpose: contacting an expedition to Clipperton Island. The beams were installed in a fixed position without rotors. After the expedition, those amateurs sold their beams or amplifiers. Second, we have all known others who conducted QSO's with foreign amateurs almost daily. Their beam antennas stayed pointed in those directions, and they became well know in those foreign lands. Yes, fixed beams are often logical ideas when they fill a need or serve a purpose.

VERY LONG WIRES, VEES, AND RHOMBICS

Super long wires, wire vee beams, and the ever-classic rhombic antenna are three popular forms of wire radiators with appeal for amateurs living in rural areas or those who are adjacent to semi-wooded locations. Assuming that one uses natural supports, "select" wire lengths, and a good tuner/transmatch, these antennas can provide good performance on several HF bands at relatively low cost. The key factors here involve spotting high tree limbs/supports in desirable positions, obtaining plenty of surplus or "hamfest special" wire, and erecting the antenna using a slingshot as discussed in the last part of Chapter Four. Considering that a full discussion of these three antenna types could fill half this book, we will highlight their basic assembly and use and let you delve further technically according to your personal interests.

If a single wire antenna that is between 4 and 10 wavelengths for its frequencies of operation is erected and RF-fed with open wire or tuned feeders, it can provide gain figures equalling two or three element beams. The wire will be directional off its "far end" at its highest used frequency, and slowly dwindle to broadside radiator when its applied frequency in only one wavelength. Because many of our HF bands are harmonically related, the use of such antennas becomes quite encouraging. Consider, for example, the 535-foot long wire illustrated in **Figure 5–12**. This dimension is approximately 2 wavelengths on 80 meters, 4 wavelengths on 40 meters, 5.5 wavelengths on 30 meters, 8 wavelengths on 20 meters, 14 wavelengths on 12 meters, and a whopping 16 wavelengths on 10 meters. The wire's gain figures will be noticed beginning at 40 meters and increasing with higher bands. The antenna is

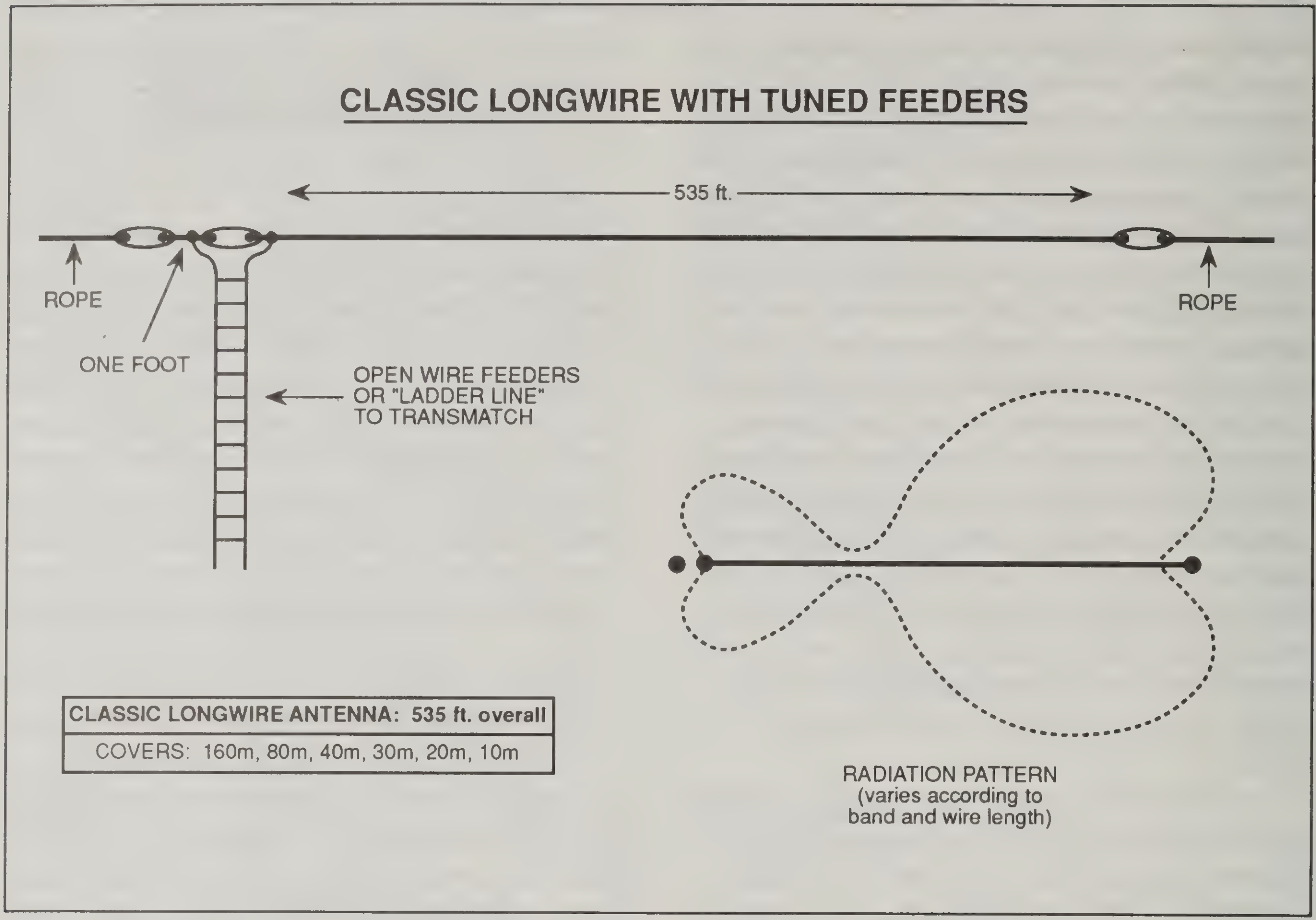

CLASSIC LONGWIRE WITH TUNED FEEDERS
535 ft.
ROPE
ONE FOOT
ROPE
OPEN WIRE FEEDERS OR "LADDER LINE" TO TRANSMATCH
CLASSIC LONGWIRE ANTENNA: 535 ft. overall
COVERS: 160m, 80m, 40m, 30m, 20m, 10m
RADIATION PATTERN (varies according to band and wire length)

Figure 5-12 *Layout and general dimensions for long wires. Shown is a classic long wire with tuned feeders.*

assembled using available wire and supports, with "one side" of the tuned feeders connected to the long wire and the "other side" connected only to the end-retaining short wire. A transmatch with balanced/tuned feeder outputs is used, and after SWR tuning, each band's coil and capacitor settings are logged for later "quick reference." If you have never used very long wire antennas, we emphasize including an outdoor spark gap to dissipate atmospheric static to ground (a ½ inch gap is typical). We also encourage adding a 2.5 mHy choke between each tuner output connection and ground. Otherwise you may be shocked (no pun intended) to recognize one or two inch sparks jumping from the feeder wire (disconnected from rig, hopefully!) during windy/inclement weather or hearing rapid rain static on your receiver during clear weather.

If you have room for additional wires of the same length in approximately similar directions, you might consider expanding the very long wire antenna into a vee beam as illustrated in **Figure 5–13**. This modification will provide an approximate three decibels improvement in signals; the equivalent to doubling your transmitted power. Ideally, the wires should be spaced 35 to 40 degrees apart and aimed toward the desired communications direction. Of course, a number of long wires or vee beams oriented toward various world areas with feed lines converging near your rig's setup would be the optimum situation. The angle of radiation or DX capacity of these wire antennas is directly related to their above ground height. This usually results in the antennas being good DX wires on 30 meters and higher, fair DX antennas on 40 meters, and good "in-country" antennas on 80 or 160 meters. Once again we emphasize inclusion of an outdoor spark gap or large antenna grounding switch for dissipating static charges when this antenna is not in use, and a 2.5 mHy choke between each feeder line and ground during on-the-air operation.

Assuming you have access to yet greater areas for antenna installations, an additional 535-foot length can be added to each "leg" of a vee beam and positioned in a "diamond" shape to create a classic rhombic antenna. This design is included in **Figure 5–14**. The added wires should also exhibit a 35- to 40-degree apex angle, and that factor "centers" on 20-meter operation with maximum gain off the rhombic's far end (unfed end). Other bands can be operated with this size rhombic; however, their radiation patterns vary and are best evaluated through experimental field strength measurements. Returning to 20 meter considerations, the 1070-foot rhombic's directivity can be reversed 180 degrees by connecting its far ends together and terminating them with an approximate 800-ohm noninductive resistance. That resistance should be capable of dissipating one-half the applied RF level. One example of this is 25,000-20,000-ohm, two watt, carbon resistors wired in parallel. That resistance/wattage would be suitable for popular 100-watt output transceivers.

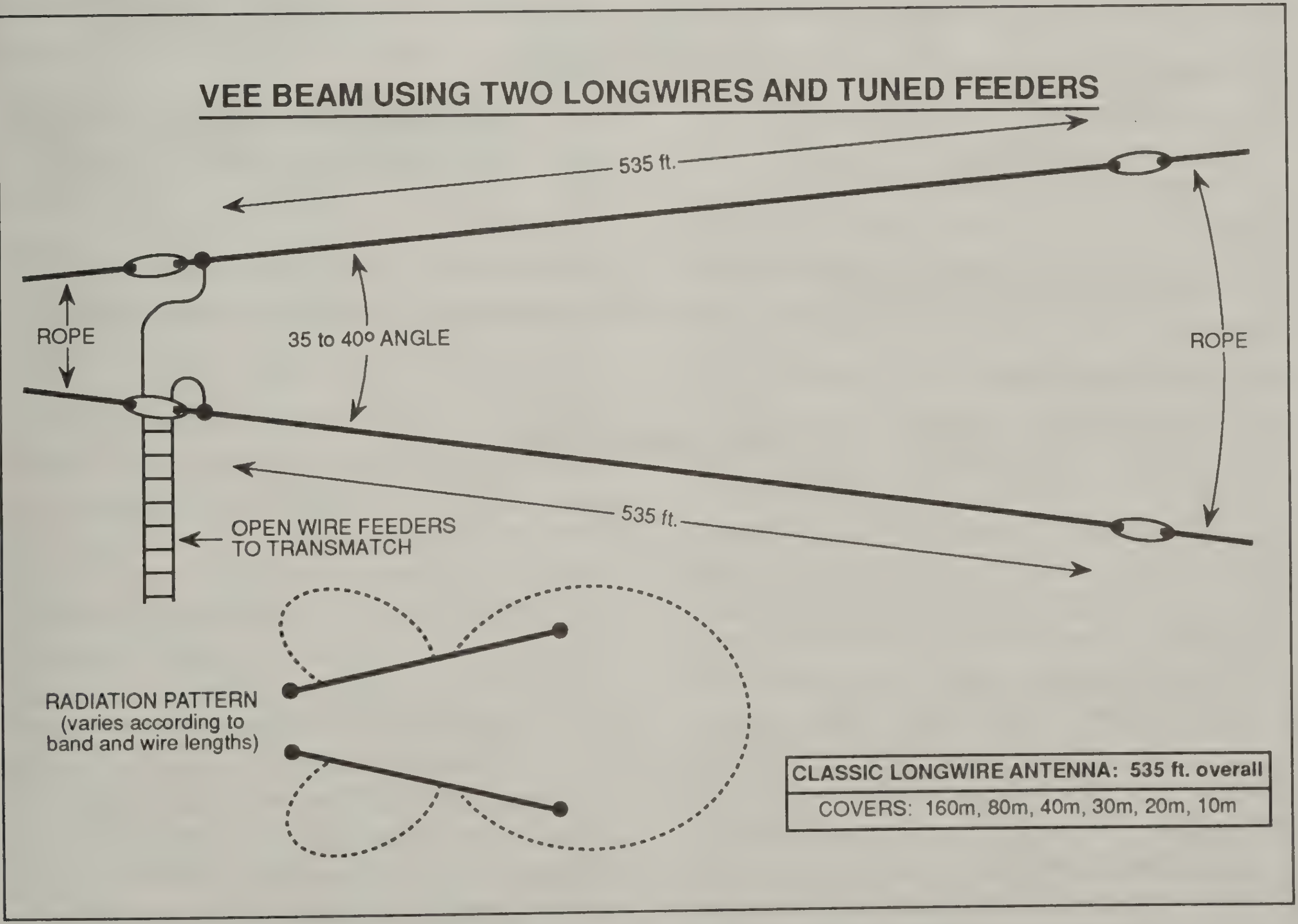

VEE BEAM USING TWO LONGWIRES AND TUNED FEEDERS
535 ft.
ROPE
35 to 40° ANGLE
ROPE
535 ft.
OPEN WIRE FEEDERS TO TRANSMATCH
RADIATION PATTERN (varies according to band and wire lengths)
CLASSIC LONGWIRE ANTENNA: 535 ft. overall
COVERS: 160m, 80m, 40m, 30m, 20m, 10m

Figure 5-13 *Layout and general dimensions for a vee beam using two long wires and tuned feeders.*

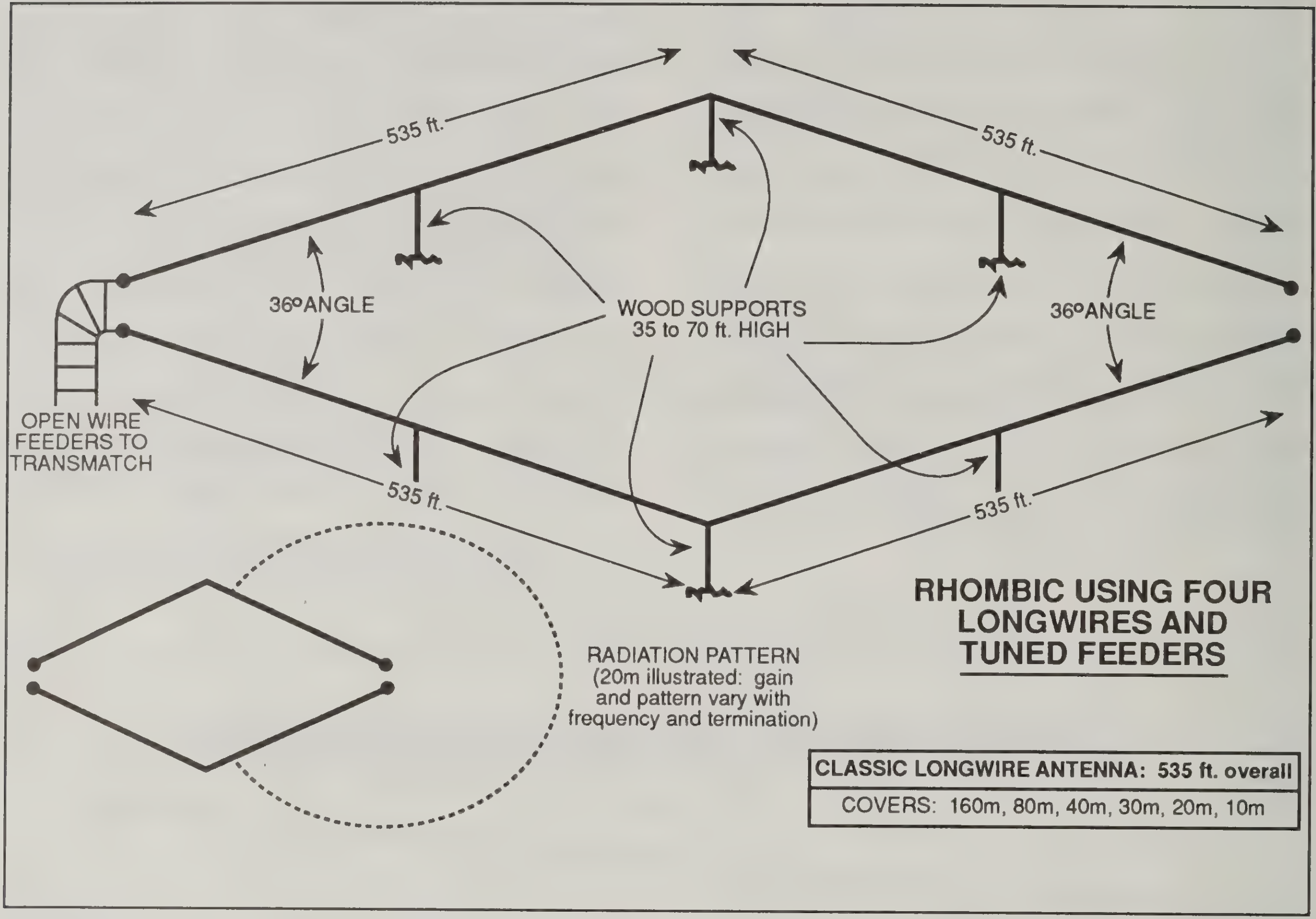


Figure 5-14 *Layout and general dimensions for a rhombic antenna using four long wires and tuned feeders.*

ANTENNA NOTES

CHAPTER SIX

INVISIBLE AND SECRET ANTENNAS

INTRODUCTION

This chapter is dedicated to assisting radio amateurs and SWL's living in apartments, condominiums, or other areas which restrict the erection of "usual" HF antennas. The information provided is intended as a working alternative for what might otherwise be dubbed as an impossible situation. We will not delve into legal, political, or social aspects of this problem; however, we must highlight two noteworthy points of interest: First, legal and social guidance regarding recent zoning actions is a growing concern for all radio amateurs, and the American Radio Relay League (225 Main Street, Newington, Connecticut 06111) can put you in touch with several legally-informed groups. Second, I personally feel that any amateur performing public service, unselfish deeds of mercy, or technical advancement activities, and who has been recognized for those commendable efforts (by newspapers, television news, etc.) would and should be appreciated and encouraged by his/her neighbors. Keep your chin up, think positively, and proceed cautiously. Assuming the previous thoughts have not yielded favorable results in your particular situation, we offer the following ideas and antenna designs to allow your operations to function in a somewhat "low profile" or "inconspicuous" manner.

If you live or move into a restricted or "uncertain" area, do not jeopardize yourself or your "secret" prematurely. You may get only one chance to erect an antenna before becoming a "neighborhood suspicion." In other words, avoid "testing the water" with a pint-size minibeam and then hope to sneak in an all-band doublet. Work your way upward in a cautious, yet confident, manner. Conduct some undercover investigating. Let a neighboring CB antenna or your own slightly large TV antenna be the guinea pig. There is one other vitally important point which must be considered at this early time: your setup must not create any form of television, telephone or stereo interference. Although an antenna may not be readily visible, RF interference is a sure giveaway! Only using one of today's fully shielded and enclosed transceivers is the first step in this direction, along with a good low pass filter and an RF-choked ground system ensuring radiation is "pure" and emanates only from the antenna. The transceiver's AC power cord (and even ground leads) can be wrapped around a two or three inch diameter toroid core placed at the rig's rear. **See Figure 6–1.** This measure will minimize stray radiation from external wires and let you concentrate on your antenna setup. That radiator, incidentally, should be placed at right angles to telephone and power lines to minimize RFI and hopefully reduce any unfortunate line noises (Antenna design and location are beginning to describe themselves, eh?).

There are several possibilities or alternatives in the area of invisible or secret antennas, and they all follow natural laws of signal radiation and reception. One might conclude that truly invisible antennas, per se, are non-

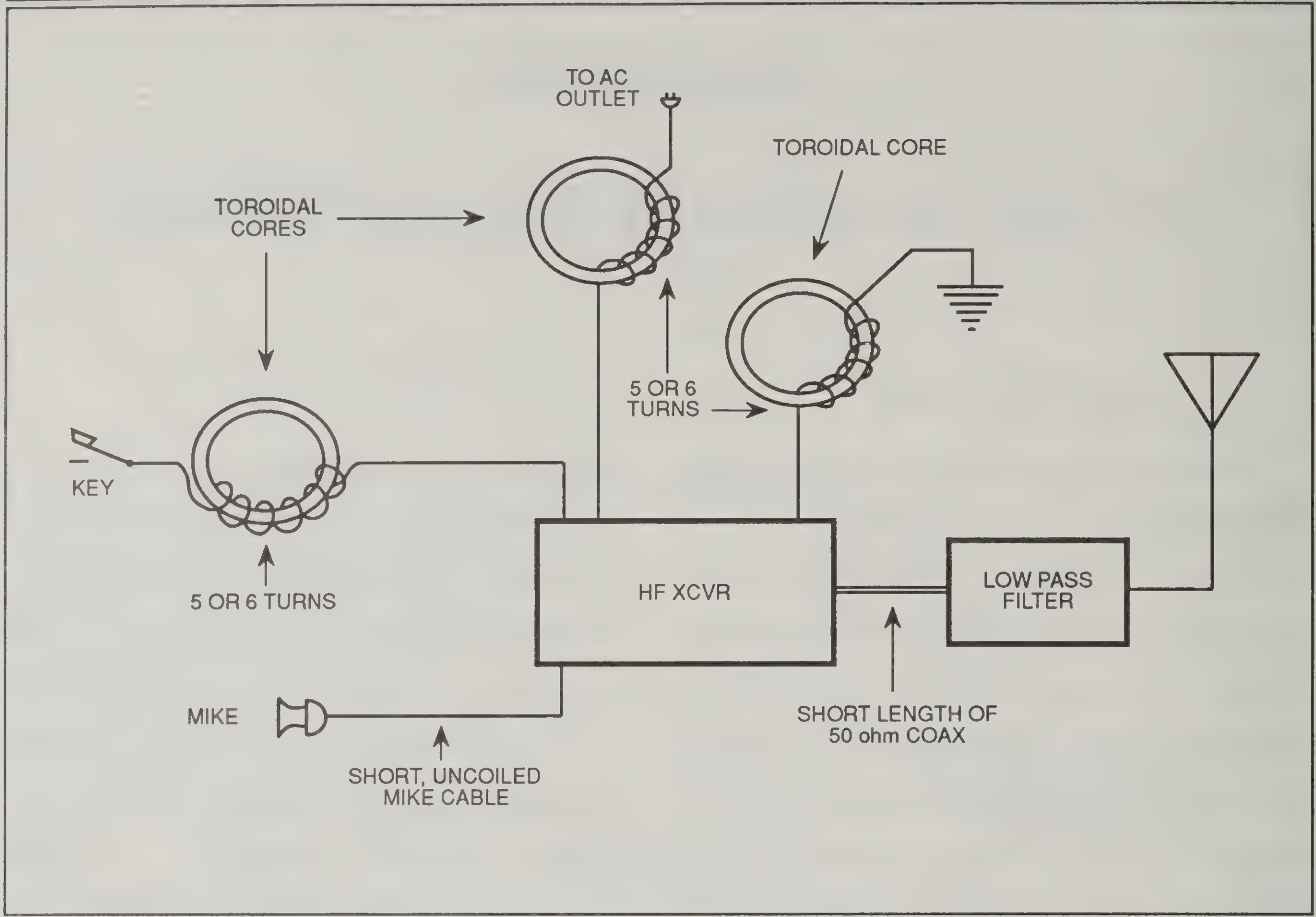


Figure 6-1 *Basic measures for minimizing stray radiations from an HF transceiver used in a "low profile" situation. Discussion in text.*

existent, but rather sky wires which survive unnoticed to the untrained eye. A curious matter, you say? Not really. A dipole constructed of number 24 enamel wire, small plastic insulators, RF-fed with super-small RG174/u coaxial cable lightly dipped in green or grey paint, and erected 30 feet or higher, blends perfectly with its surroundings. An outdoor clothes line using wire with tan insulation rather than plastic line or rope, and RF-fed by coaxial cable painted to match its supports are another possibility. Indoor antennas of the long wire, vee, or ground plane design can be used successfully in wood frame homes, and "attic installations" also yield quite impressive results. Amateurs residing on upper floors of various buildings can use antennas which are taken down when not in use such as small dipoles placed a few inches above the roof, or thin long wires erected over nearby tree tops using a slingshot. Could such "compromise" antennas perform acceptably? Considering the good results obtained from mere seven-foot whips on mobile setups as examples, we state a hearty, "You bet they do." We suggest outdoor antennas for multistory buildings because those structures include metal framings. We also emphasize using a good (non-radiating) ground system to avoid RFI generating "loops." Use several toroid cores on those wires to choke RF, use a balun to minimize feed-line radiation, and check all cables for possible resonance/radiation of spurious energy.

When erecting "secret" antennas, try to conduct outdoor work during evening or early morning hours when suspicious eyes are closed (the predawn hours around New Year's, July 4th or Labor Day are good prospects). Naturally, the antenna should be preassembled and ready for hoisting. If you use the slingshot or rod and reel installation method, try to keep the sun's light to your back and use fluorescent fishing line with chrome weights for good visibility. Secure the antenna in its final position with "camouflaged" end ties (heavy string, etc.) and enjoy the results. Beyond this point, you are on your own—study your "neighborhood acceptance/discovery" and proceed accordingly. Who knows, maybe you will soon be encouraged to erect an all band vertical or triband beam.

INVISIBLE ANTENNAS GALORE!

Contrary to possible first opinions, invisible or "secret" antennas are not significantly different from the usual types of amateur wire antennas. They may be dipoles, slopers, ground planes, delta loops, or even phased arrays which are undetectable to unsuspecting eyes. Their general design concepts merely involve using small wire such as gauge numbers between 26 and 34, tiny insulators, small coaxial cable, and possibly camouflaging paints or "unexpected supports." The use of small size wire and coaxial cable is quite suitable for RF levels up to 150 watts, and few "low profile" amateurs use higher power setups. These views (or in case of secret antennas, non-views), create new possibilities for any of the antennas described in Chapter Four. As you reconsider those antennas, also visualize their low cost when using empty sewing thread spools for insulators, heavy grey thread for end ties, and wire purchased by the half-pound roll or salvaged from junked TV yokes or transformers. It is true the wire may not stay aloft several seasons before snapping, but you will surely have a different and yet more appealing design ready to take its place at replacement time.

Again looking at the antennas included in Chapter Four, numerous new possibilities in implementation and construction will spring from the clever minds of radio amateurs. All band doublets with tuned feeders or twinlead Marconis could be assembled using small wire and two or three inch spacers of match sticks sprayed with blue and grey paint. Vertical or sloping wires can be erected along tree sides, wooden carport frames, or roof edges. Occasionally coaxial cables can be "ground camouflaged" (and protected) by threading them through discarded sections of garden hose.

On the more deluxe and/or technical side, one might set up a super-elaborate antenna system plus broadband transmitter/receiver RF sections at a select remote site and operate the station by a 10-gHz link from a den or patio. The concept here involves passing a whole HF band (or more!) from one site to the other as I. F. signals in a Gunnplexer. That arrangement may take some creative designing but visualize the results!

STICK'EM-UP ANTENNAS

The following description is not a sky wire from the wild west of yesteryear, but rather an idea for installing inconspicuous antennas in unusual places. It involves using the electrically-conductive tape employed in burglar alarm systems as an antenna's radiating elements. Rolls of this tape, along with their end connections and splices are available at hardware and variety stores coast to coast. Simply roll out a desired length, stick it to a wall or window, connect your cable, and bingo—an almost "invisible" antenna! This technique is grand for upper bands like 10 or 12 meters, but it will require quite a span for 80 meters. Nevertheless, it may be an ideal solution for getting on the air from an otherwise hopeless QTH. Trimming its ends to lower SWR is a bit unusual—use a razor blade. The only precautions you should observe are mount the antenna so it is out of reach of curious fingers and avoid mounting areas near concrete (they absorb RF energy like a sponge).

Regular formulas and dimensions are directly applicable to tape antennas; therefore, they will not be repeated here. Perhaps you will be the first in your neighborhood with an 8JK skylight or sliding glass door vertical. If your plate glass front is quite large a mini G5RV might be possible. Think creatively!

KITE OR SKY WIRE

While most secret or invisible antennas employ a combination of popular designs and barely noticeable components, there are also occasions when larger radiators may be disguised and exposed to obvious view without consequences. One such example is described in the following personal experience of author K4TWJ. Hopefully it will serve as "useful inspiration" to others facing temporary restrictions.

Several years ago I spent a summer in a somewhat isolated cottage on the Gulf Coast. There were few if any supports for antennas, plus several factors heavily discouraged their erection or, for that matter, use of any amateur radio setup. My location was ideal, only uncleared jungle, totally deserted beaches, constantly blowing winds off the ocean, tall stands of wild sea oats, and unused backwaters encompassing areas below all of the winds' directions. I assembled a large kite using newspaper, heavy sea oat stems as struts, and homemade glue. The kite flew like a Condor, and with an idea in mind, I thoroughly saturated its connecting string in the salty Gulf water before letting the skyhook "do its thing" (an easy step if you start the kite's flight from the beach; merely let a long length of string drop into the water before use). The kite's climb was phenomenal and soon it could only be seen through binoculars. I knew by the string's pull the kite would never be retrieved, so I secured it to the cottage's deck railing. Another freshly moistened string was connected between the deck tie point and indoor antenna tuner, and DXing action began. I ran less than 50 watts on 40 meters during that evening episode, yet I worked stations in South America, Africa and Europe in fine style. The tuner required adjustment every few minutes until a light shower re-moistened the string. The continuing salt spray carried by the breeze (which coated house windows) also seemed useful. I have no idea of the string's length, but a one half to two-mile distance seems logical. The tuner was of the simple "long wire or coaxial" variety, and it worked great. The string broke a day later leaving only memories and incoming QSL's.

A second and larger kite was constructed next, but this time several spools of copper wire replaced the string (I knew both kite and wire would never be retrieved, but such was the trade-off for memorable DXing). Once again the kite zipped skyward, once again binoculars were necessary for viewing, and once again the wire was secured and connected to the antenna tuner. The tuner's adjustments were significantly more stable and antenna performance was noticeably better. Although I didn't have multiband capability at that young age, the sky wire would have surely proved its benefit on 20 or 10 meters also. Last year's revisit to that beach area revealed multiple homes, condominiums, and power lines. Several miles down the beach, however, wide open spaces and unoccupied canals again beckoned to kite-equipped amateurs with modern transceivers and antenna tuners.

Although my secret antenna was a little more than an unmeasured length of wire tied to a kite and indoor tuner, its concept is shown in **Figure 6–2**. The prime factor which must always be remembered with this radiator is safety. Never raise an antenna of this nature when there is any possibility of it crossing power lines anywhere. Also know your weather. Flying long wires and thunderstorms do not mix. Old Ben Franklin was fortunate that his pants were not blown off by a direct hit. You might not be so lucky.

AN INCONSPICUOUS MULTIBAND ANTENNA

If you enjoy using today's solid state transceivers with their instant-on and no tune-up capabilities, you will surely appreciate a multiband antenna which uses full-size element dimensions and a single connecting feed line. If you are confined to a "low profile" environment, there are always questions regarding how to inconspicuously erect such radiators. One useful solution to that dilemma centers around the utilization of inexpensive four-conductor rotor cable (a flat and dull

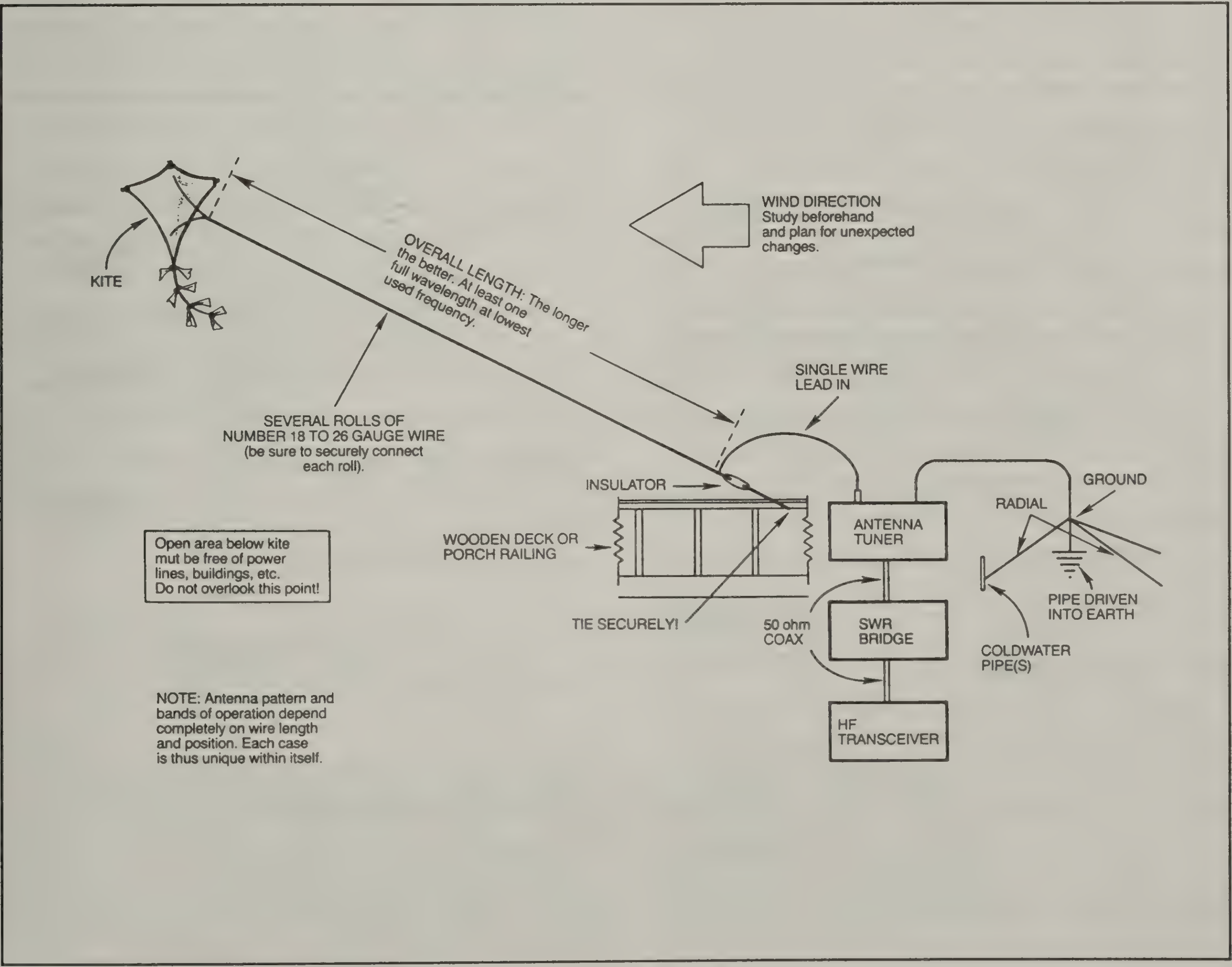
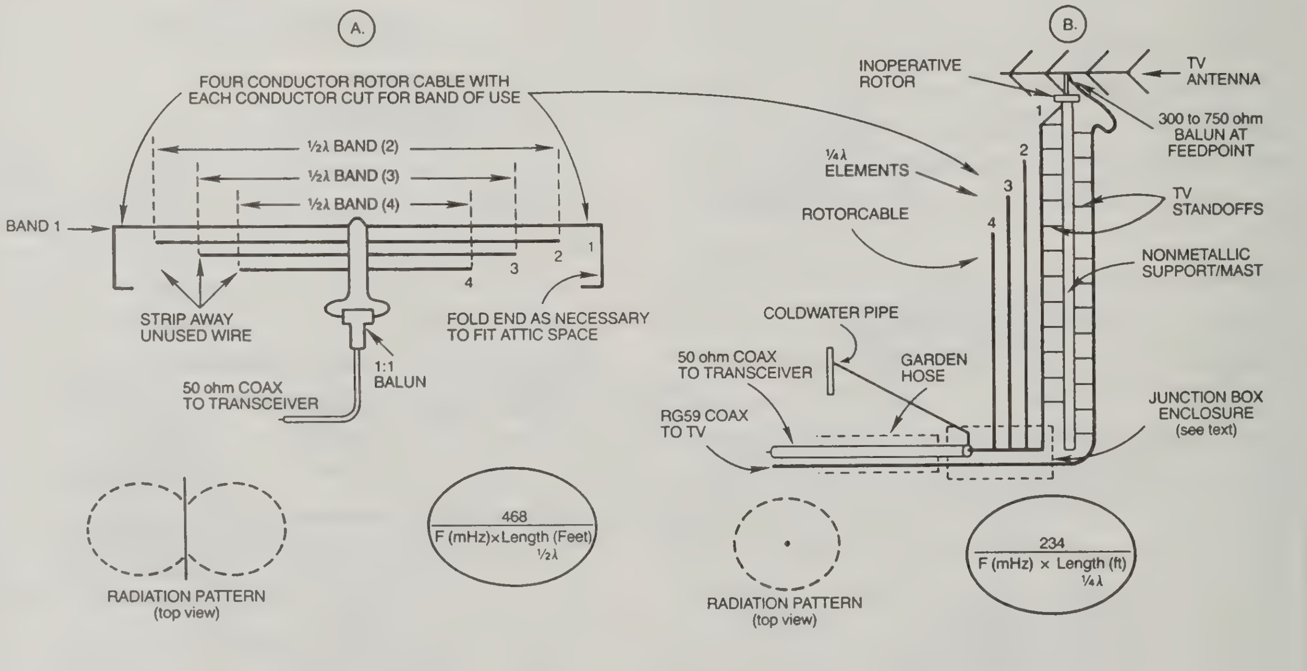

KITE
OVERALL LENGTH: The longer the better. At least one full wavelength at lowest used frequency.
WIND DIRECTION
Study beforehand and plan for unexpected changes.
SINGLE WIRE LEAD IN
SEVERAL ROLLS OF NUMBER 18 TO 26 GAUGE WIRE (be sure to securely connect each roll).
INSULATOR
WOODEN DECK OR PORCH RAILING
TIE SECURELY!
ANTENNA TUNER
50 ohm COAX
SWR BRIDGE
HF TRANSCEIVER
GROUND
RADIAL
PIPE DRIVEN INTO EARTH
COLDWATER PIPE(S)
Open area below kite mut be free of power lines, buildings, etc. Do not overlook this point!
NOTE: Antenna pattern and bands of operation depend completely on wire length and position. Each case is thus unique within itself.

Figure 6-2 *Kite supported skywire: A "disposable" antenna capable of good multiband performance.*

brown insulated wiring available at most parts stores and Radio Shack outlets). Each of the rotor cable's wires can be trimmed for operation on desired bands as available room permits, and the antenna can be installed in the attic or outdoors according to individual situations.

Two creativity-inspiring examples of our inconspicuous multiband antenna setup are shown in **Figure 6–3**. The dipole is initially constructed by cutting its full width (all four conductors) for the lowest amateur band utilized. The other three conductors are then cut in a staggered fashion for their respective bands, allowing slight "overage" in lengths to permit frequency pruning (proximity to nearby walls, rafters, adjacent cable wires and bent installation angles might alter specific lengths up to 10 percent of normal/unobstructed values (Your noise bridge and SWR meter can be used advantageously here.). Because this antenna will be operating with an "indoor handicap," the use of a center balun is highly recommended. A suitable length of low-loss coaxial cable can then connect the antenna to its mating transceiver.

An alternate approach to this rotor cable type antenna is also shown in **Figure 6–3(B)**. Here, a quarterwave outdoor multiband vertical is arranged using one's TV antenna and a non-functioning rotor as a disguise. The mast supporting the TV antenna (and amateur antenna) should be nonmetallic (i.e.,


A.
FOUR CONDUCTOR ROTOR CABLE WITH EACH CONDUCTOR CUT FOR BAND OF USE
½λ BAND (2)
½λ BAND (3)
½λ BAND (4)
BAND 1
1
2
3
4
STRIP AWAY UNUSED WIRE
FOLD END AS NECESSARY TO FIT ATTIC SPACE
1:1 BALUN
50 ohm COAX TO TRANSCEIVER
RADIATION PATTERN (top view)
468 / F (mHz)×Length (Feet) ½λ
B.
INOPERATIVE ROTOR
TV ANTENNA
300 to 750 ohm BALUN AT FEEDPOINT
¼λ ELEMENTS
TV STANDOFFS
ROTORCABLE
NONMETALLIC SUPPORT/MAST
COLDWATER PIPE
50 ohm COAX TO TRANSCEIVER
GARDEN HOSE
RG59 COAX TO TV
JUNCTION BOX ENCLOSURE (see text)
RADIATION PATTERN (top view)
234 / F (mHz) × Length (ft) ¼λ

BAND	160 meters	80 meters	40 meters	30 meters	20 meters	18 meters	15 meters	12 meters	10 meters
FREQUENCY	1.820 mHz	3.750 mHz	7.100 mHz	10.100 mHz	14.100 mHz	18.100 mHz	21.100 mHz	24.900 mHz	28.600 mHz
½λ (DIPOLE OVERALL)	257.14 ft.	124.82 ft.	65.91 ft.	46.33 ft.	33.19 ft.	25.86 ft.	22.18 ft.	18.79 ft.	16.36 ft.
¼λ (VERTICAL OVERALL)	128.57 ft.	62.40 ft.	32.96 ft.	23.16 ft.	16.60 ft.	12.93 ft.	11.09 ft.	9.40 ft.	8.18 ft.

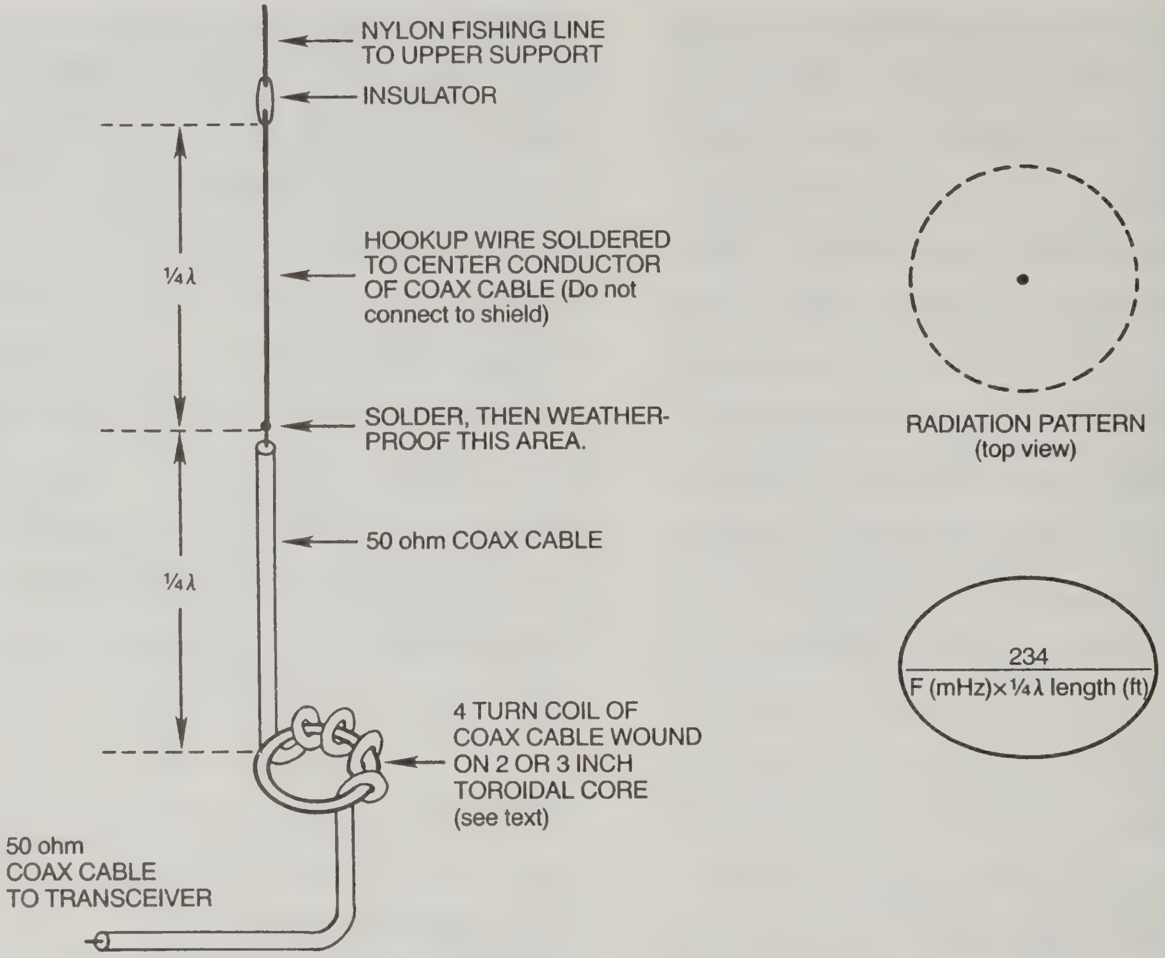
Figure 6-3 *Two forms of inconspicuous multiband antennas.*

wood, PVC, etc.); tall enough to support the rotor cable (pre-cut to bands of use), and not placed against the house. The cable's longest wire should disappear into the rotor's terminal connection area (but not connect), and its cover reinstalled to divert suspicion. The TV antenna itself should include a 300- to 75-ohm balun, permitting use of RG59 cable to a similar indoor TV balun and the TV set's antenna terminals. We also suggest wrapping that RG59 cable several times around a three-inch toroid (at the TV's balun), and using a high pass filter to avoid interference during simultaneous operations. Returning to the outdoor vertical, the stagger cut radiator can be spaced and supported using TV cable standoffs. Similar insulators on the support's other side can handle the RG59 cable. Moving to ground level, both RG59 (TV) and RG58 (amateur radio) cables can be threaded through discarded garden hose or PVC tubing buried a few inches below the surface to discourage suspicion. Likewise, a small junction box at the vertical's base can merely pass RG59 cable while providing an outlet for the vertical's ground wire (which must obviously be for TV antenna use, eh?). Assuming the junction box is coated with a thick wrapping of "Coax Seal"® and upper rotor cable cuts are lightly taped, even professional inspectors could not uncover this full-sized gem.

A QUICK AND EASY VERTICAL DIPOLE

While home antenna restrictions may be discouraging to enthusiastic HF amateurs, they surely do not preclude enjoying our grand pursuit from alternate locations such as a weekend cabin or office parking lot during the week at lunch. When compared with other leisure interests such as skiing, boating, camping, etc., that second choice/portable operation idea becomes both logical and attractive. We might also add that normally "busy" bands become calm and uncrowded during weekend hours—a special attraction for low power operators. Usually the first question typically centers around how to select an inexpensive yet effective antenna which can be quickly erected using a single support and left in place without serious concern about cost if it is destroyed. A number of old-time possibilities initially come to mind—but wait, here is a better and "full-sized" antenna that is inexpensive enough almost to be dubbed "disposable."

The vertical dipole outlined in **Figure 6–4** is constructed from readily available hookup wire, a convenient length of 50-ohm coaxial cable, and a 2- to 3-inch toroidal core. Assuming one scrounges a few "extras" or makes a quick stop by a parts store, this antenna can practically be assembled and used "right on the spot." The antenna's upper section (hookup wire area) is first cut to ¼ wavelength for the desired band of operation and connected to the coaxial cable's center conductor (notice the coaxial shield is left unconnected, but remember to fully weatherproof all this exposed area). The upper section can next be doubled back along the coaxial cable as a measuring guide, and that equal length's end marked for placing a toroidal core. If you have a roll of tape and the toroid in your pocket at that time, merely wrap a four-turn coil through the core, and the antenna is ready for installation (You did attach a PL259 to the other end before leaving the parts store, didn't you?). Attach a small insulator to a long length of nylon fishing line with a weight on its end, then toss the weighted end over a convenient tall support (An easy maneuver for 10-, 12-, or 15-meter versions, but somewhat challenging for 40- or 80-meter antennas—let your throwing arm be your guide!). After the toss, retrieve the fishing line's weighted end and use it to pull


NYLON FISHING LINE TO UPPER SUPPORT
INSULATOR
¼λ
HOOKUP WIRE SOLDERED TO CENTER CONDUCTOR OF COAX CABLE (Do not connect to shield)
SOLDER, THEN WEATHER-PROOF THIS AREA.
50 ohm COAX CABLE
¼λ
4 TURN COIL OF COAX CABLE WOUND ON 2 OR 3 INCH TOROIDAL CORE (see text)
50 ohm COAX CABLE TO TRANSCEIVER
RADIATION PATTERN (top view)
234
F (mHz)×¼λ length (ft)

BAND	160M	80M	40M	30M	20M	18M	15M	12M	10M
FREQUENCY	1.820 mHz	3.750 mHz	7.100 mHz	10.100 mHz	14.100 mHz	18.100 mHz	21.100 mHz	24.900 mHz	28.600 mHz
¼λ SECTION (Overall length is twice this figure)	128.57 ft.	62.40 ft.	32.96 ft.	23.16 ft.	16.60 ft.	12.93 ft.	11.09 ft.	9.40 ft.	8.18 ft.

Figure 6-4 *A quick and easy vertical dipole.*

the vertical dipole into position. Avoid hitting the fragile powdered iron toroid on hard objects, and you are ready for action.

The toroidal core serves to isolate or RF-separate the transmission line and radiating sections of the antenna. Suitable cores include those of Amidon's T–200 series, or you can salvage an applicable one from a discarded TV yoke (save the wire wound on the yoke also, it is good antenna material). If the core is a two-piece toroid, use fiberglass or filament tape to reassemble it. An extra wrapping around the core also provides bump/shock protection. If the completed antenna needs frequency pruning, merely lower it by its fishing line and trim the upper section as required. Finally, we encourage you to use amateur radio wisely but to stay on the air as much as possible. If that calls for invisible/disguised/disposable antennas, so be it. It has often been radio amateurs who, during a crisis, provided a service to the people needing it the most. As radio amateurs, we fulfill a real need.

CHAPTER SEVEN

ANTENNA TUNERS AND TRANSMATCHES

INTRODUCTION

The antenna tuner, matchbox, or transmatch, is one of amateur radio's most useful accessories. Originally designed for operation with "open air" and long wire antenna systems, today's tuners are used with everything from triband beams to tuned-line doublets to providing optimum coupling between solid state transceivers and their mated antenna systems. This renewed popularity in antenna tuners apparently evolved from our desire to comfortably operate across full allocations of several bands without outdoor adjustments, and it is being supported by a wide variety of both commercially manufactured and homemade tuners. Among the kaleidoscope of popular units are tuners with built in SWR bridges and/or wattmeters, optional or included baluns for tuned lines, coaxial switches for quick multiple antenna selection, and even electronically driven capacitors which automatically sense SWR and then adjust themselves accordingly. It should be considered, however, that tuners used with common but "challenging" antennas (such as narrow banded dipoles or beams with high SWR's) are not necessarily "ideal solutions" but rather solutions when ideals cannot be easily achieved.

Most basic antenna tuner circuits consist of a coil and capacitor(s) combination arranged to match a wide variety of input impedances to a transceiver or linear amplifier's low impedance output. Physical size of antenna tuner components (capacitor plates/spacing, coil size/gauge wire, etc.) determine a tuner's RF power handling capabilities. "Legal limit" tuners with their related massive components, are naturally more expensive than smaller low power equivalents. Extra features such as internal antenna switches and meters obviously escalate the cost of those units; however, they do provide "all in one box" convenience which can be a blessing to many installations. Because antenna tuners usually employ simple circuits and large components, their home construction is both logical and an ideal means of self-expression. After assembly and testing, it is also appealing to incorporate a multiple antenna switch, a bypass switch and SWR bridge (either homemade or a commercial unit removed from its original case) into the tuner.

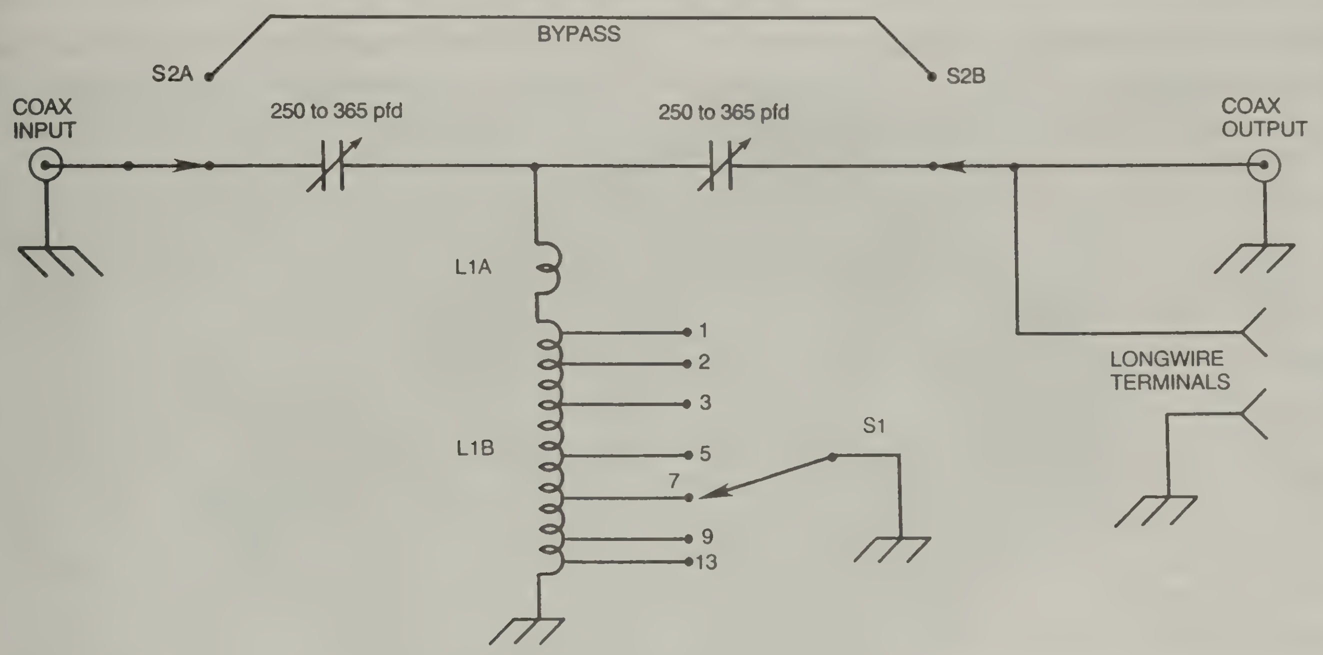
If you have never used an antenna tuner, the following basic advice is offered for your assistance. An SWR bridge or forward/reflected wattmeter is used for monitoring/checking tuner adjustments. If that item is not included in the station's transceiver or tuner, an "outboard" equivalent should be coax-connected between the two units. If a linear amplifier is used, the SWR bridge connects between its output and the tuner (be sure the bridge can survive full amplifier output). Bear in mind the tuner's main function: matching "oddball" antenna impedances to a rig's fixed low impedance output. Think of it as a variable transformer for RF energy with front panel controls you adjust. Establish a systematic procedure for making those adjustments (such as coil tap first, antenna capacitor second, and transmitter capacitor third). Use only enough RF power for accurate SWR meter reading until an acceptable match is achieved, then "double check" readings at increased output. Allow plenty of time for a rig's power stages to cool between tuning adjustments and meter readings. Once satisfied with tuner adjustments, log control settings and place them in a nearby conspicuous spot for later quick reference. Beyond this point, we emphasize studying your tuner's instruction manual and following its particular directions for operation.

A VERSATILE ANTENNA TUNER YOU CAN BUILD

Considering the financial advantages and relative ease of constructing one's own antenna tuner, details highlighting a unit of time-proven design are included on the following pages. This tuner is capable of operation on 160 through 10 meters (including WARC bands) and can be assembled using components obtained from either a "junk box" or hamfest flea market. There are a number of options which can be employed in parts layout and enclosures, such as securing a blank cabinet "shell" to match other station gear and cutting/painting a matching front panel, or assembling the tuner inside a large chassis (complete with bottom cover plate and rubber feet). If this idea is pursued, the tuner could also serve as an elevating block positioned beneath other station equipment. Why build a quality item in any discarded box when you can make it a product of beauty?

The schematic diagram of our versatile antenna tuner is shown in **Figure 7–1**. A pair of 365-pfd variable capacitors and a tapped coil of the homemade or commercial variety comprise the basic design, while a hefty multicontact switch and bypass switch plus RF connectors complete the unit. The somewhat large tuning capacitors such as those used in older tube radios are good choices for this tuner, provided RF power does not exceed 300 to 400 watts. Variable capacitors with wider plate spacings and three and one-half inch diameter inductors using number 10 or larger wire can extend that figure to the legal 1500-watt limit. Before purchasing or installing capacitors, we suggest checking plate alignment by connecting an ohmmeter between the stator and the rotor and tuning the capacitor through it full range. Infinite resistance should be indicated on the meter. Notice that both sides of the variable capacitors plus their shafts must be insulated from the metal cabinet in our described tuner. This is achieved by using standoff insulators or mounting both capacitors and coil directly to a one-half inch sheet of plastic which is then glued to the cabinet's shell. Insulated shaft couplings are also used between capacitors and knobs to prevent front panel "arc through." The coil in our 300/400-watt version consists of 25 turns of number 14 copper wire wound to occupy two inches length on a one and three-eighths inch diameter pill bottle. Any coil form between one and one-fourth and three inches should work equally well, however. The pill bottle in our unit is glued to the bottom plastic sheet for stability. All tuner wiring should be direct point-to-point construction using number 14 or larger solid wire. Use ample (but not excessive) amounts of heat and solder, and always strive for smooth rounded connections without sharp, corona-favoring imperfections. Upon completion, double check your work for accuracy, then connect the station's gear and evaluate the tuner's performance (use only a few watts of power and a sensitive SWR bridge until you are comfortable with the tuner's operation).

Begin adjustments by presetting both capacitors to half mesh and the coil to maximum inductance. While listening to incoming signals on the station's transceiver, vary coil



C1, C2:	250 TO 365 pfd VARIABLE CAPACITOR WITH WIDE PLATE SPACING (Broadcast type usable to 800 watts)
L1A:	2 TURNS #14; ½″ DIAMETER, ½″ LONG
L1B:	25 TURNS #14 WOUND ON PLASTIC FORM. COIL IS 1⅜″ DIAMETER, 2″ LONG, WITH TAPS AT 1, 2, 3, 5, 7, 9, and 13 TURNS.
S1:	RF-CAPABLE MULTIPOLE NONSHORTING SWITCH.
S2A, B:	DPDT RF-CAPABLE SWITCH

Figure 7-1 *A versitile antenna tuner for 160 through 10 meter operations. Unit can be inexpensively homemade.*

settings and then vary “antenna side” and “transmitter side” capacitors until signal strengths peak. Next, apply very low RF output from the transceiver and “fine tune” capacitor settings for lowest SWR. If an acceptably low SWR is not achieved, cut off transmitter output, switch the coil to the next position, and readjust the capacitors as previously described.

A substantial number of these antenna tuners have been assembled and used by amateurs in both fixed and portable setups. They have been operated with everything from kite long wires to beams and bed springs. They have been kilowatt-abused and car-trunk-tortured, yet they have always performed in a commendable manner. What more could one ask from such a reasonable investment. **See Figure 7–2.**

A BALUN ADAPTER FOR OPEN WIRE FEEDERS

A few of the antenna designs included in this book, plus some of those gracing the pages of various monthly magazines, occasionally employ wire feeders or “ladder line” instead of conventional coaxial cable. A “deluxe” tuner with balanced outputs is normally required with these transmission lines; however, that feature can be easily and inexpensively added to an “unbalanced” or coaxial-type tuner. In other words, a low expenditure and a couple of hours effort can turn your existing tuner into a full-featured unit usable with nearly any antenna system. Sound appealing? Read on!

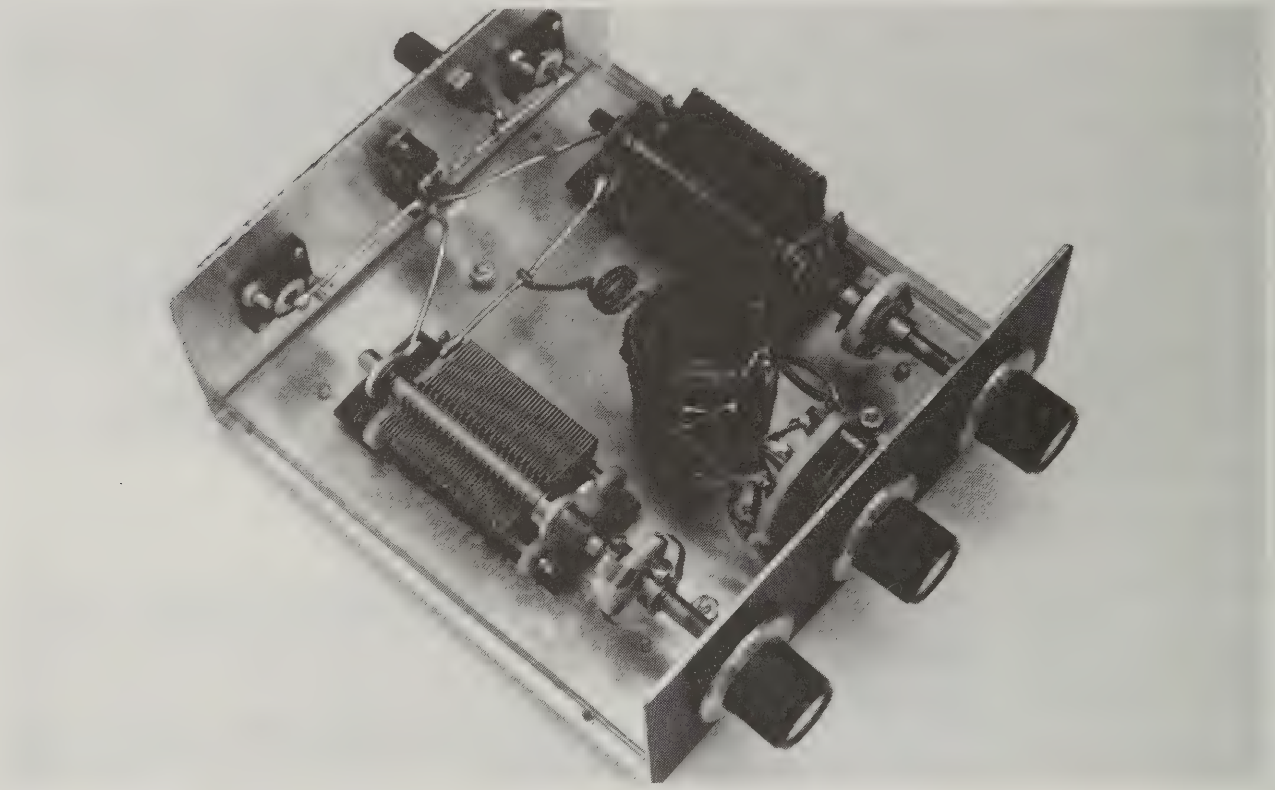


Figure 7-2 *Inside view of the versatile antenna tuner. Variable capacitors are mounted on thick plastic sheet and insulated from the cabinet via non-conductive shaft couplings. Note the use of heavy wire with direct point-to-point connections.*

This easy-to-assemble adapter consists of a bifilar wound coil on a two and one-fourth inch toroidal core. The homemade 4:1 balun is then connected between a tuner's coaxial output (or single wire and ground binding posts) and the tuned line. **See Figure 7–3.** The adapter can be mounted in a separate box or added inside one's existing tuner. Remember to allow plenty of cabinet/metal support clearance to avoid detuning or arcing, and use connectors appropriate for your particular setup. The T–200–2 toroid is available from Amidon Associates, 12033 Otsego Street, North Hollywood, California 91607, or from Palomar Engineers, 1924 F, West Mission Road, Escondida, California 92025. Many of the popular amateur radio dealers and parts outlets also carry these cores. Often packaged along with the cores is the necessary Teflon-covered wire for winding bifilar coils (two simultaneous, or parallel, windings). The coils are wound "dual fashion" as shown in **Figure 7–3**, using number 12- or 14-gauge Teflon-covered wire (an insulating material capable of withstanding RF heating effects). Approximately 13 turns permits 10- through 40-meter operation, with 16 turns extending that range to 80 meters, and 20 turns also including 160 meters. The toroidal balun will handle up to 500 watts. If the coil is wound over two T–200–2 cores which are held together with fiberglass tape, the power rating will extend to one kilowatt. If three cores are taped together and a larger gauge of Teflon-covered wire is used, the balun can handle 1500 watts of RF energy. Install the balun as previously discussed, then follow its connected tuner's adjustments in their normally employed manner. This versatility adds a new dimension in capabilities to one of amateur radio's most useful accessories, the classic antenna tuner. May your signals always radiate strong and clear!

HOW TO PROOF AND RECORD YOUR ANTENNA'S PERFORMANCE

Many professional broadcast engineers unanimously agree that accurately maintained records and diaries of a station's performance and history are a priceless asset. Over a period of years, this information becomes a transmitter's and antenna's "voice" to technicians. It tells the effects of ground variations on SWR, the life of tubes, cable weaknesses, plate and antenna current deviations, and much more. New equipment can also be compared with that proven reference for directly evaluating changes and station improvements. With only slight modifications, those same record-keeping concepts can be applied to our amateur radio setups with very beneficial results. The key is retaining your records in one well-established place or book that will stay with you through many years of operating log filings and equipment updates. A sample record form which can be modified according to personal preference is included on the following pages of this book. You can use it as a starting point if our

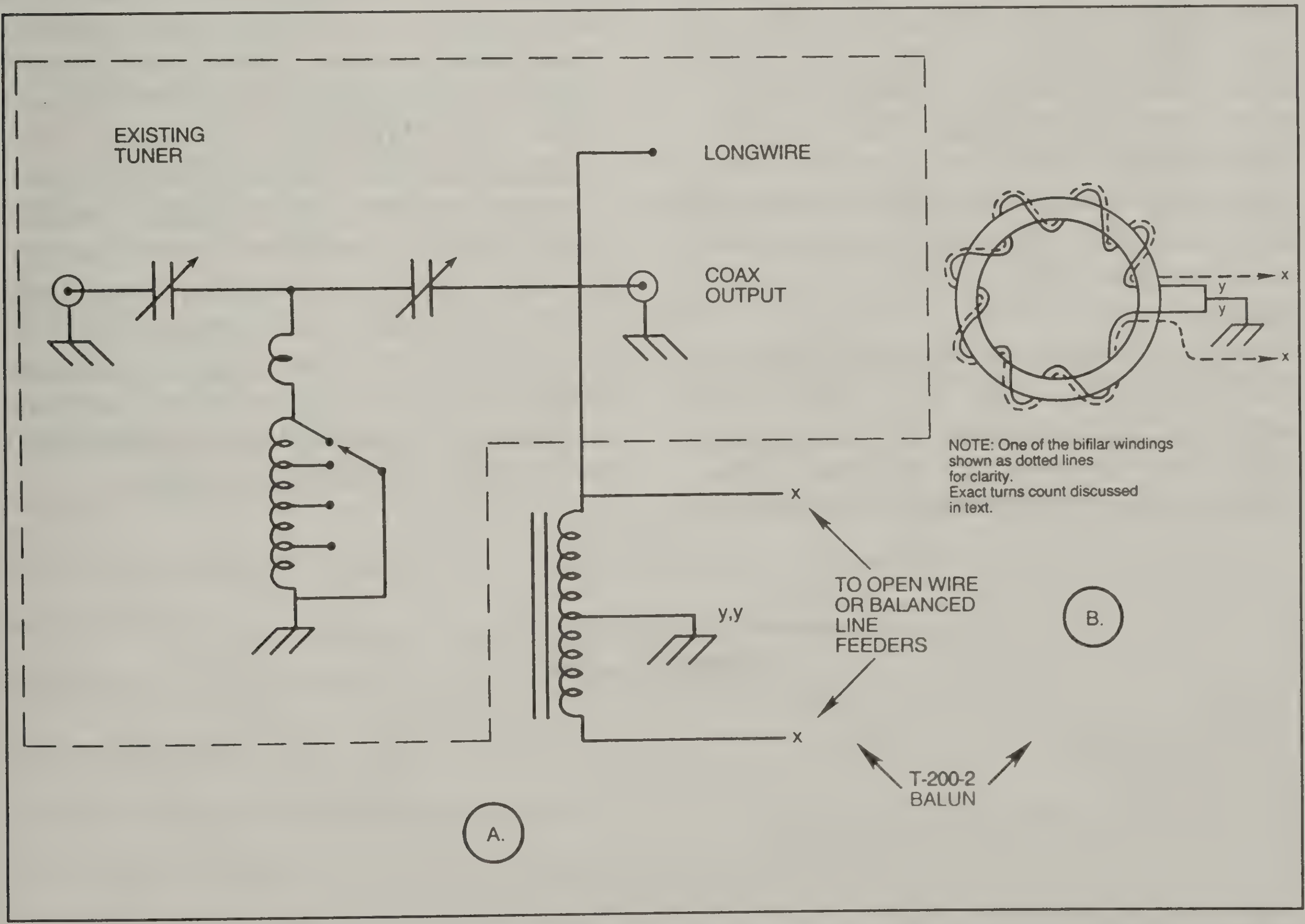

EXISTING
TUNER
LONGWIRE
COAX
OUTPUT
y
y
x
x
NOTE: One of the bifilar windings shown as dotted lines for clarity.
Exact turns count discussed in text.
x
y,y
TO OPEN WIRE
OR BALANCED
LINE
FEEDERS
B.
x
T-200-2
BALUN
A.

Figure 7-3 *A balun adapter for open-wire feeders. (A) Schematic for antenna tuner. (B) The toroidal core may be added to any basic tuner.*

book will be in your library for years, or you can set up your own station diary. The main point is beginning that diary now, not one or two years later. Every day is a learning experience. Document it!

A good way to begin your station's diary is by measuring and recording various aspects of its performance at the present time. Start with your main setup and favorite antenna, then work your way through second rigs and alternate antennas. Mobile rigs and portable setups can be checked and recorded at the end. Do not leave any stones unturned. You will appreciate the efforts several years hence, especially when you trade cars or move the home QTH.

Log the date and year, your equipment types and knob settings, antenna, balun, and feed-line condition, and antenna tuner settings for various bands (if used). Measure each antenna's SWR at the low, middle and upper band ranges, your transmitter's output power, and your linear amplifier's output (if used). These last measurements are very useful for monitoring "big tube" life. All of these measurements are not mandatory at once. Make the endeavor educational and enjoyable. Remember amateur radio is a fun hobby.

Author Dave Ingram has been keeping a station diary for many years, and it now serves as a vital comparison of rigs and antennas. For example, a Drake TR-4, Collins amplifier and Mosley TA-33 worked over 200 countries from a heavily wooded QTH during the early 1970's. The antenna's SWR changed from 1.3 to 1.5 when the array was lowered from 65 to 35 feet. A later equipment change did not noticeably alter DXing effectiveness, but swapping to a Hy-Gain Thunderbird beam a year later made a noticeable improvement. Looking back over the years also indicates that output power level changes from 500 to 700 watts made little, if any, true difference in DX effectiveness. A later addition of a full legal-limit amplifier, however, was a different story. Most noticeable in that diary is a simple dipole erected quite a few years ago. It was cut at 66 feet for 40 meters, installed 35 feet above ground and used with a National NCX-5 (It is a pity I did not record its feed-line length.). The antenna's SWR was exactly 1:1 (one in a million!) and increasing the SWR bridge's sensitivity did not even budge reflected power measurements. The rig and antenna performed like magic and worked DX like a bandit. The transceiver's RF amplifier ran unusually cool and was very efficient. There is really something indescribably fantastic about a perfectly matched antenna and rig! Although numerous attempts have been made to recreate that amazing antenna setup, it has yet to be exactly duplicated. Maybe one of your homemade sky wires will "fill that bill." Good luck in the pursuit, and send us a copy of its documentation.

ANTENNA NOTES

RECORD OF STATION AND ANTENNA PERFORMANCE

(Sample)

DATE __________ ANTENNA# __________

ANTENNA TYPE AND DIMENSIONS: __________

TYPE AND LENGTH OF COAX: __________

WHEN COAX PURCHASED AND FROM WHOM: __________

LOCATION OF ANTENNA, HEIGHT ABOVE GROUND, AND ROUTING OF COAX: __________

SWR MEASUREMENTS

DATE	BAND	LOW END	MIDDLE OF BAND	HIGH END OF BAND

STATION # __________ DATE __________

TRANSCEIVER USED: __________

PLATE AND LOAD SETTINGS: __________

LINEAR AMPLIFIER USED: __________

TUBE REPLACEMENT RECORD: __________

OUTPUT POWER: __________

PLATE AND LOAD SETTINGS: __________

AC LINE VOLTAGES: __________

SPECIAL NOTES AND EQUIPMENT CHANGES: __________

DATE OF SPECIAL NOTES: __________

RECORD OF STATION AND ANTENNA PERFORMANCE

(Sample)

DATE

ANTENNA#

ANTENNA TYPE AND DIMENSIONS:

TYPE AND LENGTH OF COAX:

WHEN COAX PURCHASED AND FROM WHOM:

LOCATION OF ANTENNA, HEIGHT ABOVE GROUND, AND ROUTING OF COAX:

SWR MEASUREMENTS

DATE	BAND	LOW END	MIDDLE OF BAND	HIGH END OF BAND

STATION #

DATE

TRANSCEIVER USED:

PLATE AND LOAD SETTINGS:

LINEAR AMPLIFIER USED:

TUBE REPLACEMENT RECORD:

OUTPUT POWER:

PLATE AND LOAD SETTINGS:

AC LINE VOLTAGES:

SPECIAL NOTES AND EQUIPMENT CHANGES:

DATE OF SPECIAL NOTES:

RECORD OF STATION AND ANTENNA PERFORMANCE

(Sample)

DATE ______________________ ANTENNA# ______________________

ANTENNA TYPE AND DIMENSIONS: ______________________

TYPE AND LENGTH OF COAX: ______________________

WHEN COAX PURCHASED AND FROM WHOM: ______________________

LOCATION OF ANTENNA, HEIGHT ABOVE GROUND, AND ROUTING OF COAX: ______________________

SWR MEASUREMENTS

DATE	BAND	LOW END	MIDDLE OF BAND	HIGH END OF BAND

STATION # ______________________ DATE ______________________

TRANSCEIVER USED: ______________________

PLATE AND LOAD SETTINGS: ______________________

LINEAR AMPLIFIER USED: ______________________

TUBE REPLACEMENT RECORD: ______________________

OUTPUT POWER: ______________________

PLATE AND LOAD SETTINGS: ______________________

AC LINE VOLTAGES: ______________________

SPECIAL NOTES AND EQUIPMENT CHANGES: ______________________

DATE OF SPECIAL NOTES: ______________________

RECORD OF STATION AND ANTENNA PERFORMANCE

(Sample)

DATE ANTENNA#

ANTENNA TYPE AND DIMENSIONS:

TYPE AND LENGTH OF COAX:

WHEN COAX PURCHASED AND FROM WHOM:

LOCATION OF ANTENNA, HEIGHT ABOVE GROUND, AND ROUTING OF COAX:

SWR MEASUREMENTS

DATE	BAND	LOW END	MIDDLE OF BAND	HIGH END OF BAND

STATION # DATE

TRANSCEIVER USED:

PLATE AND LOAD SETTINGS:

LINEAR AMPLIFIER USED:

TUBE REPLACEMENT RECORD:

OUTPUT POWER:

PLATE AND LOAD SETTINGS:

AC LINE VOLTAGES:

SPECIAL NOTES AND EQUIPMENT CHANGES:

DATE OF SPECIAL NOTES:

CHAPTER EIGHT

COMMERCIAL WIRE ANTENNAS AND ACCESSORIES

INTRODUCTION

Antennas and related signal-radiating accessories are unquestionably the oldest, largest, and most consistently popular commercial markets in amateur radio. They are areas that affect each of us in one way or another because we all use wire, insulators, coaxial cable, connectors, and a dozen other items on almost a daily basis. That statement is true for amateur stations, commercial setups, and mobile systems too. In light of those facts, this section presents a small overview of several popular manufacturers producing ready-to-install wire antenna systems and antenna-related accessories. Since new companies enter this field every month, it is easy to accidentally overlook one or two; therefore, we also encourage you to check monthly magazines for more information.

The benefits of purchasing "ready-made" wire antennas of your favorite style include: proven results, foolproof assembly, and obtaining all of the necessary parts in one package. It is true that assembling your own homemade antenna may be slightly less expensive, but "package deals" are often hard to beat for convenience. Somehow there are always two or three small yet vital items we overlook or forget when purchasing antenna materials piecemeal. Additionally, today's popular style of "cocoon living" produces a high interest in telephone ordering and doorstep delivery rather than chasing rainbows around town. The choice is ultimately personal preference, so sit back and relax while scanning our list of manufacturers. Getting on the air with a high-performance wire antenna has never been more convenient and attractive.

A BUYER'S GUIDE FOR WIRE ANTENNAS AND ACCESSORIES

The following is a guide to help in your selection and purchase of wire antennas and accessories.

AMP SUPPLY COMPANY

Amp Supply Company, a popular manufacturer of high power linear amplifiers for amateur use, produces a completely assembled G5RV wire antenna. Their package includes 102 feet of copper wire, 31 feet of heavy duty 300-ohm line, 70 feet of RG-8X coaxial cable, insulators, connectors, and a matching transformer. **See Figure 8-1.** The antenna handles 2 killowatts PEP and works all bands from 3.5 to 30 MHz. It can also be used as a Marconi antenna on 160 meters. For more information, contact: Amp Supply Company, 6307 Chapel Hill Road, Raleigh, NC 27607 (Phone 1-800-346-5701).

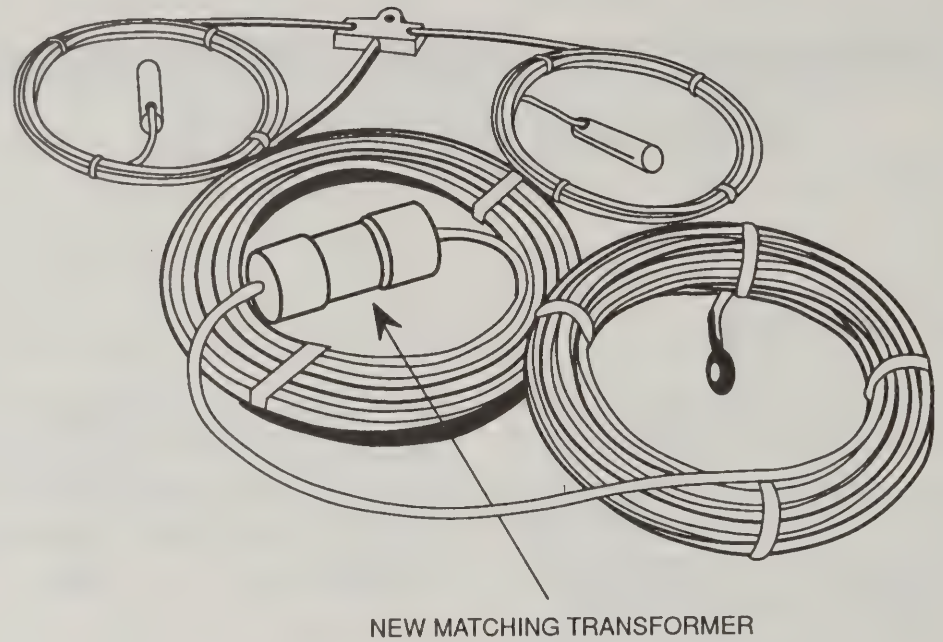


Figure 8-1 *The AMP Supply G5RV antenna. The system is supplied complete and ready to install.*

ANTENNAS WEST

Antennas West produces a very attractive line of sky wires and accessories, and their motto of "fastest antennas in the west" is well founded. Antennas West also produces a quick launch kit that can be purchased separately or as part of an antenna package itself. The quick launcher includes a wrist rocket, launching weight and trailer line, pull-up ropes, illustrated instructions, and a bucket for carrying everything to the new antenna site. Antennas West states that one person can install an antenna in 15 minutes with the kit.

Popular sky wires available from Antennas West include a Multiband QRV that works 160 through 10 meters, a Half-Square QRV monobander, and several styles of the G5RV. The antennas are supplied with kink-proof wire, weather seals, 70 feet of RG-8X cable, and presoldered connectors. They are real gems for field day or expeditions. Just go outside with their "bucket" and your antenna is up in a flash. Other items available include a half-size G5RV that works 40 through 10 meters, a quarter-size G5RV that covers 20 through 10 meters, and a Marconi adapter kit for extending the the antenna's low ranges by one band. For more details (One dollar brings you their full catalog.), contact: Antennas West, Dept. 7, Provo, Utah 84603-1144 (Phone 1-801-373-8425).

CERTIFIED COMMUNICATIONS

Certified Communications, better known as "The Wireman," handles a full line of top-grade antenna materials for homebrewers, full antenna packages for "one stop shoppers," and several very impressive accessories. The Wireman (Pres Jones) attends a large number of hamfests, so obtaining your desired items is a snap. Certified Communications' "components" include both solid and stranded copper wire (the stranded type is woven in a special tight manner for long-term durability), and several top-grade cables. The Wireman's coaxial cable is specially made with maximum shielding and polyvinyl chloride/noncontaminating jackets. They also have a new "poor man's hardline" cable that is great. If you are looking for top-notch items to build your antenna, Certified has them.

Certified's antenna kits include a 40 and 80 meter dipole, a 5-band sloper or vertical, the G5RV, and The Wireman's Flat Top Special. The last item is a classic all-band doublet. It includes 135 feet of wire, 75 feet of 450-ohm ladder line, insulators, 100 feet of sun-proof rope, and complete instructions—all at a very economical price.

In the "special accessory" category, The Wireman has a full line of center insulators and SPI-RO baluns. These items feature a highly efficient design that noticeably improves performance. Prefer to build your own balun? Certified has ready-to-assemble kits at very attractive prices.

If you are interested in a genuinely top-notch antenna noise bridge, check out the "Tennatest" unit distributed by Certified Communications. It is an absolute gem. **See Figure 8-2.** This unit measures the radiation resistance and resonant frequency of

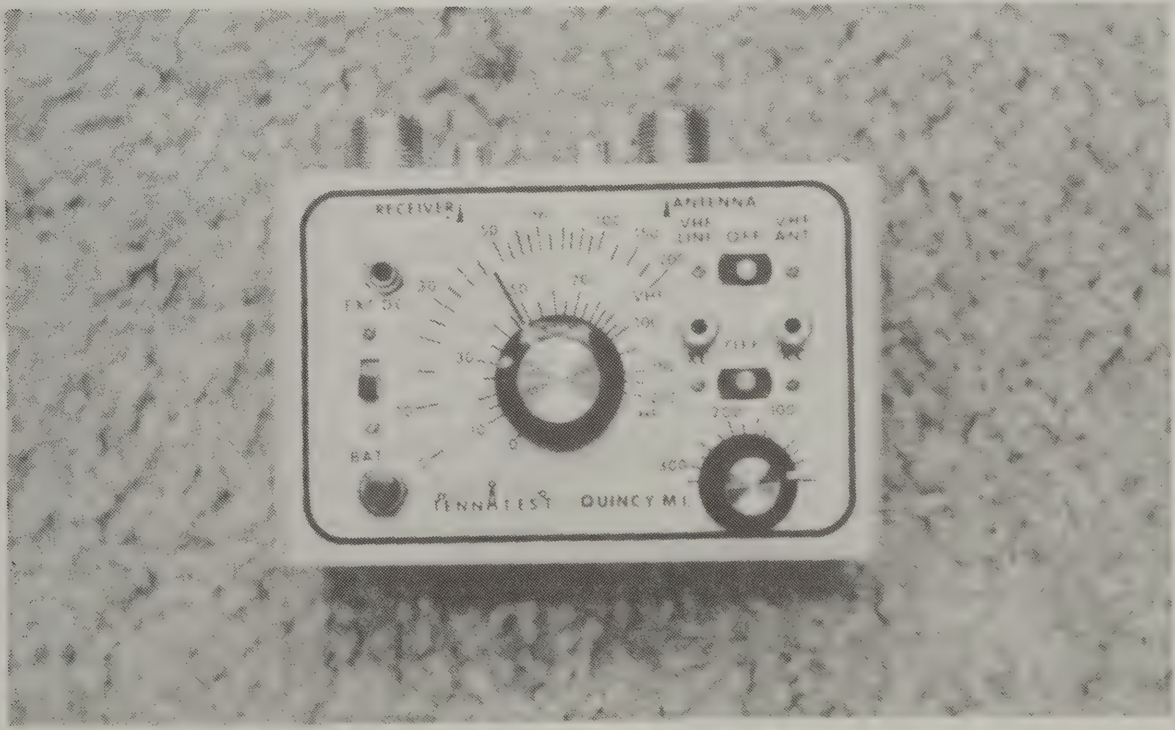


Figure 8-2 *The Tennatest universal bridge for antenna measurements. The unit is distributed by Certified Communications of South Carolina.*

almost any antenna including dipoles, beams, longwires, verticals, whips, you name it. The Tennatest can also be used as a tuner-tuner—that is, it indicates the proper control settings on your antenna tuner for a desired band/frequency of operation without transmitting a QRM-generating signal. This unit also measures electrical lengths of coaxial cable, it will determine unknown variable capacitor values, and even indicate the resonant frequency of a tuned circuit in which that capacitor is placed. For more information, write: Certified Communications, 261 Pittman Road, Landrum, SC 29356 (Phone 1-800-727-WIRE).

GARANT ENTERPRISES

Garant Enterprises, located in Canada, manufactures four all-band wire antennas that receive very enthusiastic comments about their performance from users. The antennas are designated GD6, 8, 7, and 9. The first two models are 137 feet in length; the last two (7 and 9) are 255 feet long. Garant's ads describe them as a coax-fed Windom dipole—evidently a Canadian version (but not a copy) of the Carolina Windom. Look over Garant's ads and user testimonials in the monthly amateur magazines. These antennas really seem to be DX go-getters. For more details, contact: Garant Enterprises, 227 Country Blvd., Dept. 32, Thunder Bay, Ontario, P7A 7M8, Canada (Phone 1-807-767-3888).

MISSION COMMUNICATIONS

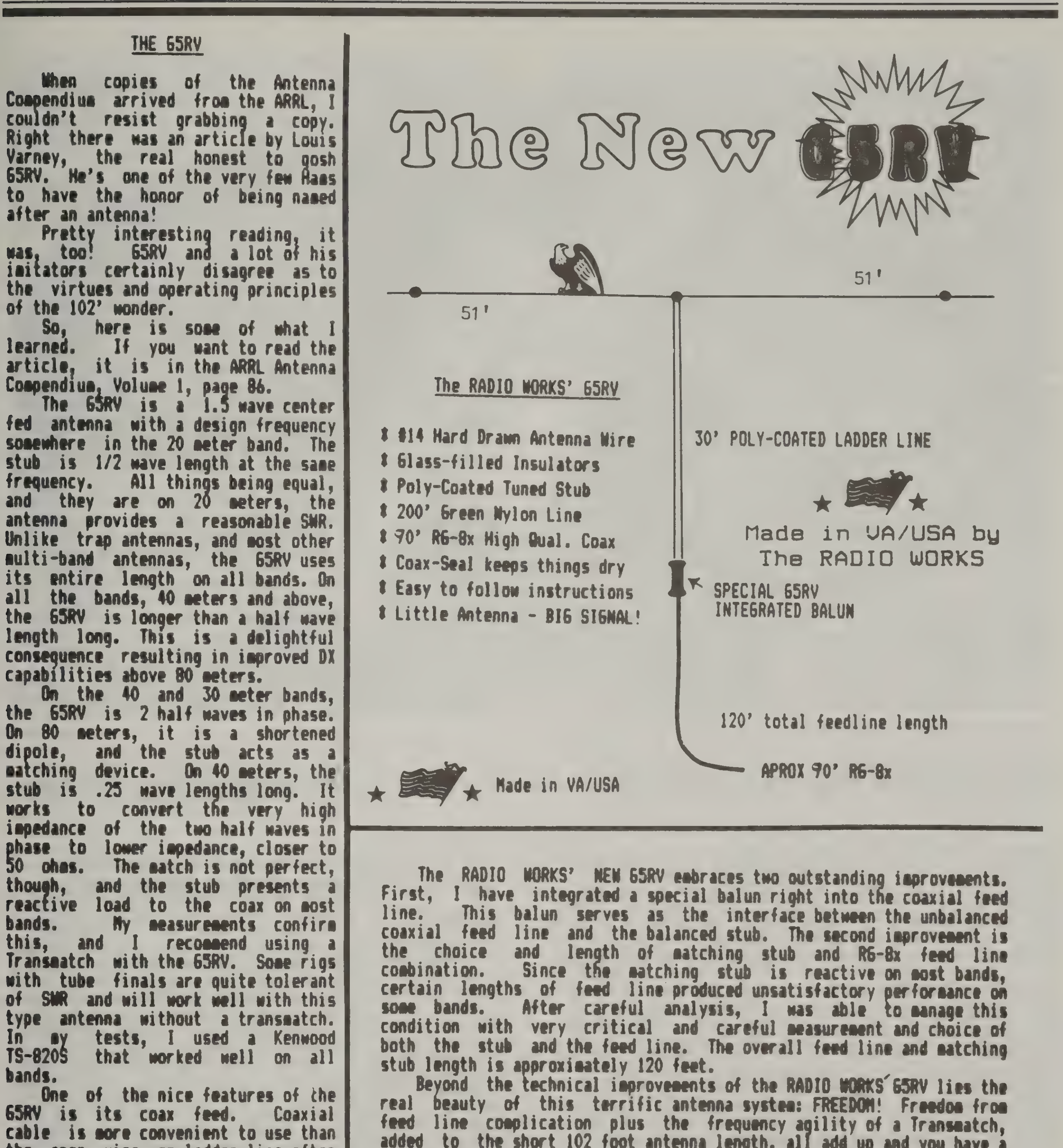
Mission Communications manufactures some interesting Double Bazooka antennas for 80, 40, or 10 meters. By the time you read this, they may have expanded their line to include 30, 20, and 15 meters. The name "Double Bazooka" was originally used several years ago for an MIT-designed wire antenna that worked like a champ. If this antenna is any relation, it is a winner. If you have tested it, let us know your opinion. For details, contact: Mission Communications, 11903 Alief-Clodine, Suite 500, Houston, TX 77082 (Phone 1-713-879-7762).

THE RADIO WORKS

The Radio Works company is one of The United States' most well known names in wire antennas and accessories. Their reputation for top quality is well established. Their products sell quickly, and they ship orders the same day they are received. You are always guaranteed "fresh stock"—an important point for coaxial cable in particular.

Radio Works carries an extensive line of preassembled wire antennas, everything imaginable in antenna parts for hobbists, and over ten different models of baluns. If these folks don't have it, you don't need it! Looking through their catalog is an inspiration in wire antennas that is irresistible and downright exciting. You see full sketches and details of their "live wire" loops, super loops, Zepps, Super Zepps, G5RVs, phased dipoles, slopers, verticals, and much more. As an example, a page of their catalog is shown in **Figure 8-3**. Having difficulty locating ladder line, nylon rope, or "dog bone" insulators? Call the Radio Works.

The Radio Works always has today's hottest wire antennas in full production and a few "new creations" under study. As this book is being written, their leading item is the new Carolina Windom. As shown in **Figure 8-4**, the Radio Works package for this antenna includes their own specially designed center matching unit, feed-line isolator, coaxial cable, wire, insulators, and weatherproofing Coax Seal. An impressive eight-page book of facts on the Carolina Windom is also available from the Radio Works. It explains the antenna as a combined horizontal and vertical radiator of very high efficiency. The Radio Works' Carolina Windom was also reviewed



THE G5RV

When copies of the Antenna Compendium arrived from the ARRL, I couldn't resist grabbing a copy. Right there was an article by Louis Varney, the real honest to gosh G5RV. He's one of the very few Hams to have the honor of being named after an antenna!

Pretty interesting reading, it was, too! G5RV and a lot of his imitators certainly disagree as to the virtues and operating principles of the 102' wonder.

So, here is some of what I learned. If you want to read the article, it is in the ARRL Antenna Compendium, Volume 1, page 86.

The G5RV is a 1.5 wave center fed antenna with a design frequency somewhere in the 20 meter band. The stub is 1/2 wave length at the same frequency. All things being equal, and they are on 20 meters, the antenna provides a reasonable SWR. Unlike trap antennas, and most other multi-band antennas, the G5RV uses its entire length on all bands. On all the bands, 40 meters and above, the G5RV is longer than a half wave length long. This is a delightful consequence resulting in improved DX capabilities above 80 meters.

On the 40 and 30 meter bands, the G5RV is 2 half waves in phase. On 80 meters, it is a shortened dipole, and the stub acts as a matching device. On 40 meters, the stub is .25 wave lengths long. It works to convert the very high impedance of the two half waves in phase to lower impedance, closer to 50 ohms. The match is not perfect, though, and the stub presents a reactive load to the coax on most bands. My measurements confirm this, and I recommend using a Transmatch with the G5RV. Some rigs with tube finals are quite tolerant of SWR and will work well with this type antenna without a transmatch. In my tests, I used a Kenwood TS-820S that worked well on all bands.

One of the nice features of the G5RV is its coax feed. Coaxial cable is more convenient to use than the open wire or ladder line often used in all band antennas. Also, a lot of Transmatches do not have balanced output and many that do, shouldn't. The RADIO WORKS' version of the G5RV does not require a balanced output tuner. You can use it with almost any Transmatch, including that neat little "automatic tuning unit" that some rigs now offer.

One short caveat though, the VSWR may, under some conditions, still get a little out of the range of some "automatic tuners".

The New G5RV

The RADIO WORKS' G5RV

- #14 Hard Drawn Antenna Wire
- Glass-filled Insulators
- Poly-Coated Tuned Stub
- 200' Green Nylon Line
- 90' RG-8x High Qual. Coax
- Coax-Seal keeps things dry
- Easy to follow instructions
- Little Antenna - BIG SIGNAL!

★ ★ Made in VA/USA

★ ★ Made in VA/USA by The RADIO WORKS

The RADIO WORKS' NEW G5RV embraces two outstanding improvements. First, I have integrated a special balun right into the coaxial feed line. This balun serves as the interface between the unbalanced coaxial feed line and the balanced stub. The second improvement is the choice and length of matching stub and RG-8x feed line combination. Since the matching stub is reactive on most bands, certain lengths of feed line produced unsatisfactory performance on some bands. After careful analysis, I was able to manage this condition with very critical and careful measurement and choice of both the stub and the feed line. The overall feed line and matching stub length is approximately 120 feet.

Beyond the technical improvements of the RADIO WORKS' G5RV lies the real beauty of this terrific antenna system: FREEDOM! Freedom from feed line complication plus the frequency agility of a Transmatch, added to the short 102 foot antenna length, all add up and you have a real WINNER!

The performance is similar to that of our "Double Zepp" on most bands.

PUT UP A RADIO WORKS' G5RV AND GET READY TO LOG SOME GREAT SIGNAL REPORTS. Be sure to answer the QSL requests!

STAND OUT FROM THE CROWD
WITH THE OUTSTANDING NEW G5RV!

The RADIO WORKS Box 6159 Portsmouth, VA. 23703 (804) 484-0140

Figure 8-3 *A sample page from the Radio Works impressive antenna catalogue.*

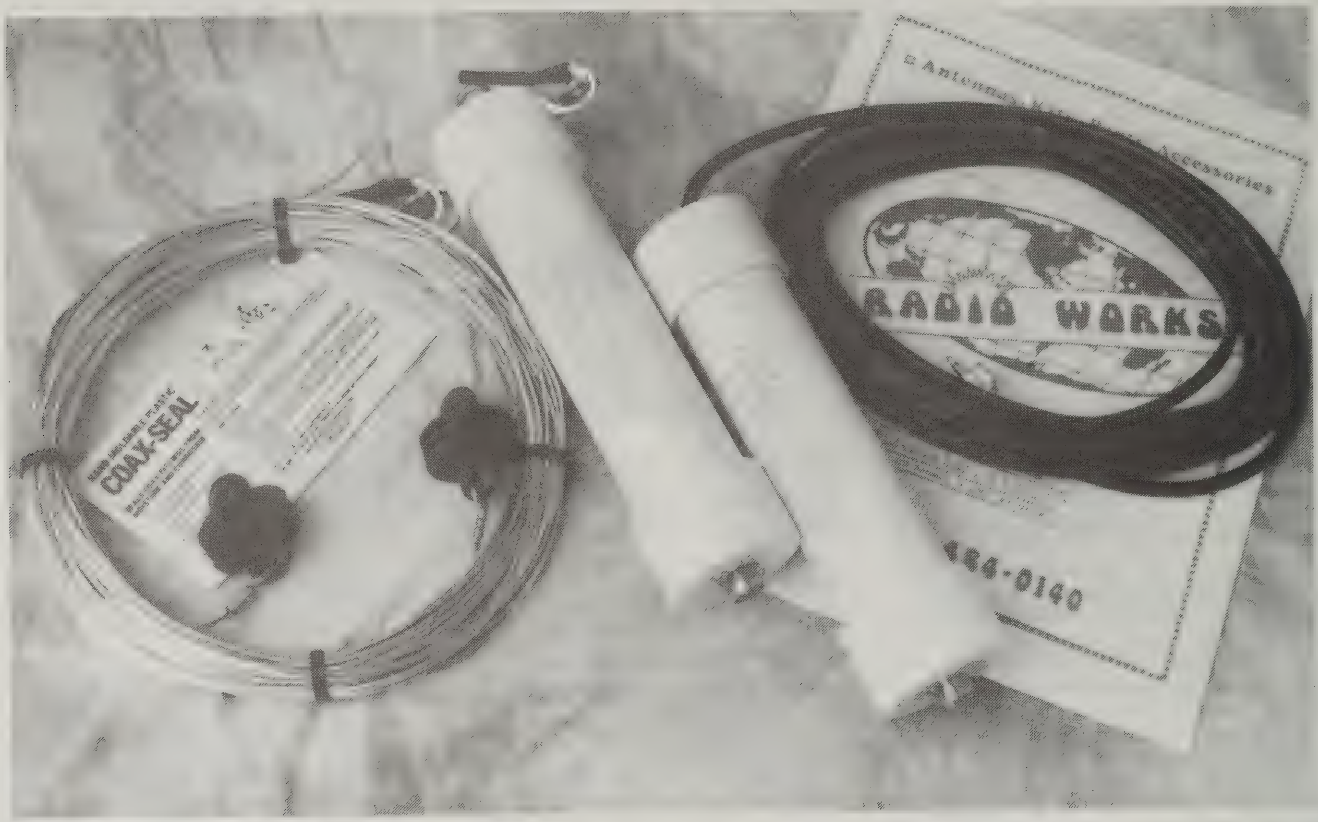


Figure 8-4 *The Radio Works company's Carolina Windom antenna package. The system is complete and works beautifully!*

by several noted amateurs, and reports consistently reported gain figures well above the G5RV antenna. Indeed, the antenna was found almost equal to a triband beam, except that the Windom was not able to rotate and did not exhibit front-to-back ratio. All facts considered, however, that is a tremendous endorsement for a simple wire antenna. It makes you think twice about investing a small fortune in a beam and tower.

Some recent interesting additions to the Radio Works are baluns with internal L/C compensating networks for widest bandwidth with lowest SWR and twin core baluns with an "X" design for superb feed-line isolation. These are the best units we have seen for avoiding core saturation at high power levels. For more information and/or a catalog, contact: The Radio Works, Box 6159, Portsmouth, VA (Phone 1-804-484-0140).

SPI-RO MANUFACTURING, INC

This company is based in North Carolina and produces an impressive line of wire antennas, parts, and baluns. Their antenna materials are both available "direct" and through authorized distributors such as Certified Communications and The Radio Works. SPI-RO's single band dipole kits are available for all HF bands, plus their trap dipoles cover 10 through 160 meters in several styles and sizes. Trap verticals and slopers that easily erect between a ground post and nearby tree limb are also featured SPI-RO items. Another attractive item is SPI-RO's limited space antenna that is only 70 feet overall and works 160 through 10 meters. The "Pro" series of SPI-RO baluns are widely known for their superb performance. Good items at fair prices. For more information, contact: SPI-RO Manufacturing, Inc., P.O. Box 5500, Lakeland, FL 33807 (Phone: 1-813-647-7925).

VAN GORDEN ENGINEERING

The Van Gorden name is an old-time favorite among wire antenna enthusiasts, and their Hi-Q baluns are quite well known. These broadband baluns are small, lightweight, and effective from 3 to 40 MHz. Other Van Gorden items include dipoles for all HF bands, parallel and shortened dipoles, fanned or parallel-wire dipoles, and dipole shorteners. A clever all-band dipole, factory-assembled and ready to install, is also available. Need nylon rope, wire, insulators, or connectors? Van Gorden has them. For more information write: Van Gorden Engineering, P. O. Box 21305, South Euclid, OH 44121.

ALPHA DELTA COMMUNICATION, INC

Lightning and electromagnetic pulse protection is, and should always be, an important consideration in any amateur radio setup. While some operators think of that protection mainly in terms of "direct hits," we must realize such views are only one side of a coin. Surges and spikes initially can go unnoticed while their damaging results accumulate to the point where we realize something is seriously wrong and expensive repairs become unavoidable. Need we mention that surge and spike damage also increases directly with antenna height? Indeed, such transient charges and spikes are the most often overlooked reasons for antenna trap and balun failures. Disconnecting your antennas and unplugging your equipment from AC lines when they are not in use is a very logical idea. An ounce of prevention is always worth ten pounds of cure.

What about those "unrealized" spikes from distant storms while we are on the air? An electrical storm can be at full force only a few miles from our QTH while we grin, tune, and chase DX; our rigs cringe under the needles of transient voltages poking at their transistors' delicate bases. Enter Alpha Delta's Transi-Trap Surge Protectors which are simple little spike-discharging boxes that insert at your rig's antenna connector and short damaging pulses to ground. The Alpha Delta units include a replaceable cartridge that shorts when "hit" alerting you to that fact while protecting your gear. They cannot save a high-in-the-sky balun, but they can help you sidestep expensive "indoor" repairs. For more details, contact: Alpha Delta Communications, Inc., P.O. Box 51117, Phoenix, AZ 85076 (Phone: 1-602-966-2200).

MFJ ENTERPRISES

This company is based in the deep South and needs little introduction to many amateurs. Indeed, MFJ's antenna tuners and antenna related accessories are found in amateur radio setups around the world. Their product line is quite extensive, and you get a substantial quantity of electronic components for your money. MFJ products also carry an impressive 30-day trial that is hard to beat.

Approximately ten models of antenna tuners were available from MFJ as this book was being written. The various models give you a wide choice of power ratings, SWR metering, cross needle wattmeters, antenna switching, balanced and/or unbalanced outputs, and overall costs. The latest and greatest antenna tuner is the MFJ Model 986 shown in **Figure 8-5**. This unit will handle up to 3 kilowatts and includes a cross-needle SWR/wattmeter that reads average or peak RF levels. Yes, you can use it to measure your SSB rig's PEP output. The 986's main feature is its simple two-knob tuning. A husky differential capacitor and massive roller inductor are used in a "Tee" network that matches almost any antenna: dipoles, loops, multiband wires, triband beams, verticals, bedsprings, window screens, and chicken coops. You simply "roll off" the inductance you need, rotate the variable capacitor, and Bingo, a perfect SWR. Make a note of the tuner's knob setting and inductor's counter number for fast band swaps later. These tuners are dandy if you have a narrow band 80-meter dipole or triband beam and an SWR-sensitive solid state transceiver. You can use them to zip from CW to SSB portions of the band for big-time DXing. The 986 tuner also includes a new style current balun for use with balanced-feeder doublet antennas and a built-in six position antenna switch. Nice!

Another quite popular MFJ antenna tuner is the Model 949C/Versa Tuner II shown in **Figure 8-6**. This 300-watt unit includes a cross-needle SWR/wattmeter, a six-position antenna switch, plus a built-in dummy load and 4:1 ratio balun. It matches any kind of antenna imaginable just like the previously highlighted 986, and its balun provides direct connections for balanced-line doublets. The 949C is perfect for "barefoot rig setups." Other MFJ models are also available with basic SWR meters, without meters, without coaxial switches, etc.

If you travel, like to operate portable rigs, or use random wire antennas with a barefoot transceiver for impromptu operating stints, MFJ's Model 16010 random-wire tuner

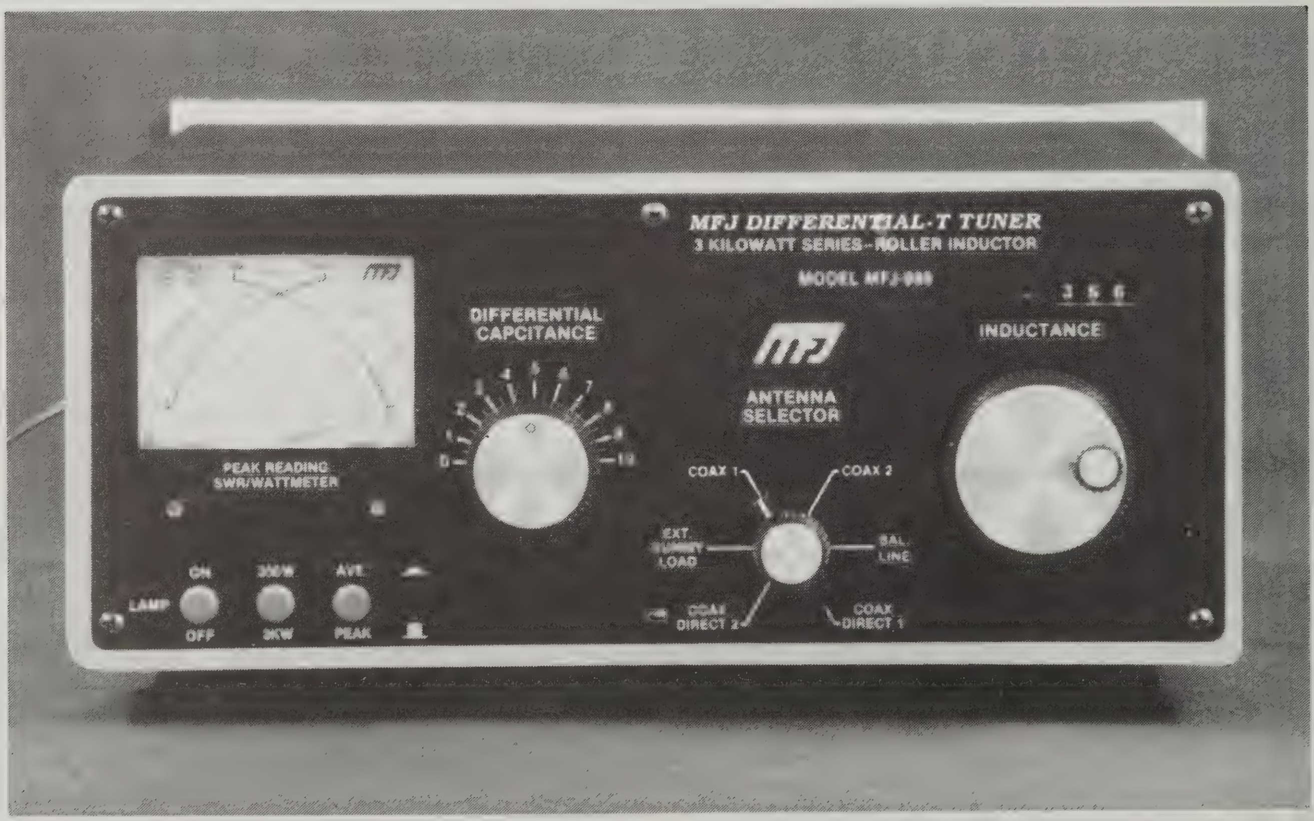


Figure 8-5 *The MFJ Model 986 Antenna Tuner features peak reading SWR/wattmeter, current balun, six-position antenna switch, and easy two-knob tuning.*

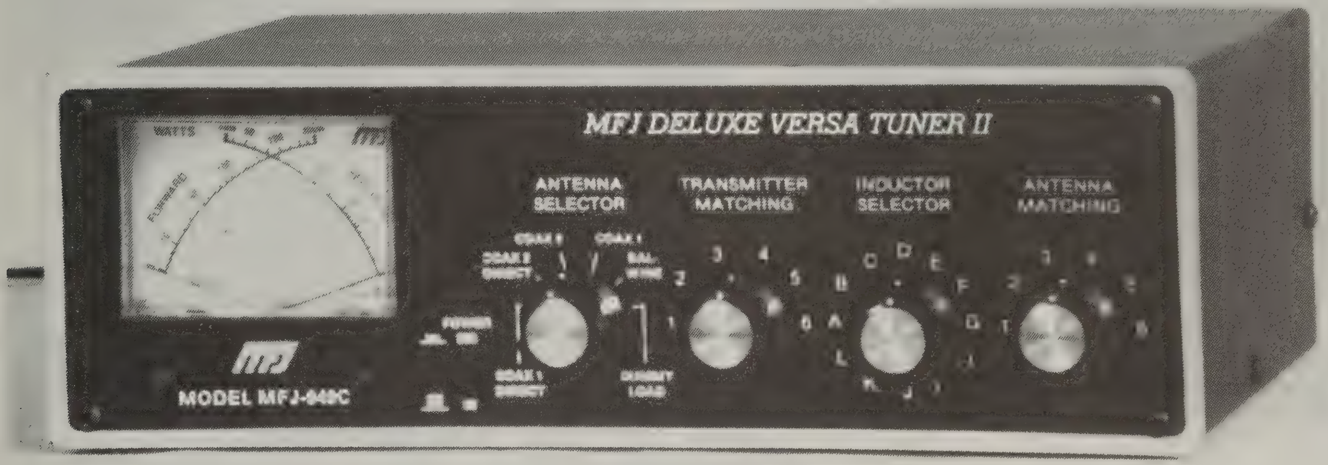


Figure 8-6 *The MFJ Versa Tuner II is a 300-watt unit with cross-needle metering and six-position antenna switch.*

shown in **Figure 8-7** is a gem. This little tuner almost fits in your pocket (2' X 2' X 3'), and it matches high or low impedances for working 1.8 to 30 MHz with a random-length wire. The unit handles up to 200 watts of RF output.

Remember the cross-needle SWR/wattmeter featured in MFJ's 986 and/or 949C tuner? It is also available as a stand-alone unit. **See Figure 8-8.** The meter reads 200 or 2000 watts and shows both forward and reflected power in a single glance.

Are the coaxial cables behind your desk a mess? Eliminating the "rat's nest" is a cinch. Install MFJ's Model 1704 coaxial switch shown in **Figure 8-9**. This heavy-duty item will last for many years while creating a clean layout. Unselected antennas are grounded, plus a center "Off" position grounds all antennas for lightning protection.

Achieving a true electrical ground is always tricky, especially if your setup is on an upper floor. Wires connected to ground also have an unfortunate habit of being resonant on one or two bands resulting in undesired ground radiation, RF feedback, and TVI. The solution? Install MFJ's Model 931 artificial ground unit shown in **Figure 8-10**. This unit electrically places your rig near actual earth ground potential even when a true ground is not possible. The unit also tunes out undesired reactances of counterpoise systems. For more information on all MFJ items, contact: MFJ Enterprises, Box 494, Mississippi State, MS 39762 (Phone 1-800-647-1800).

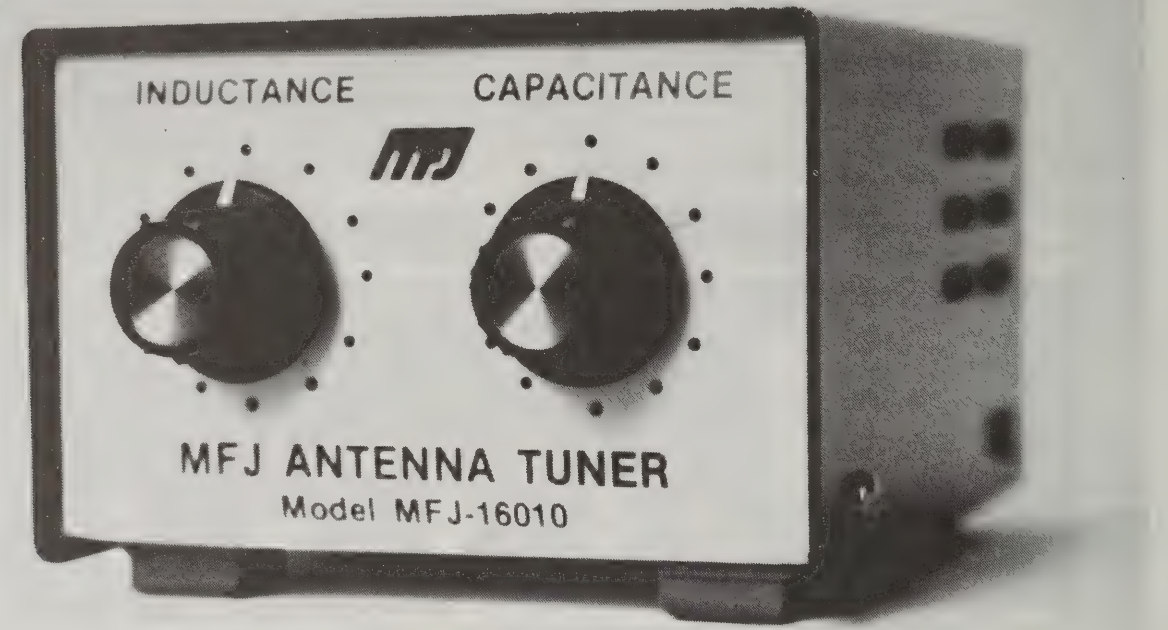


Figure 8-7 *Using random wires for portable and/or field day operations is a breeze with this pocket-sized MFJ tuner.*

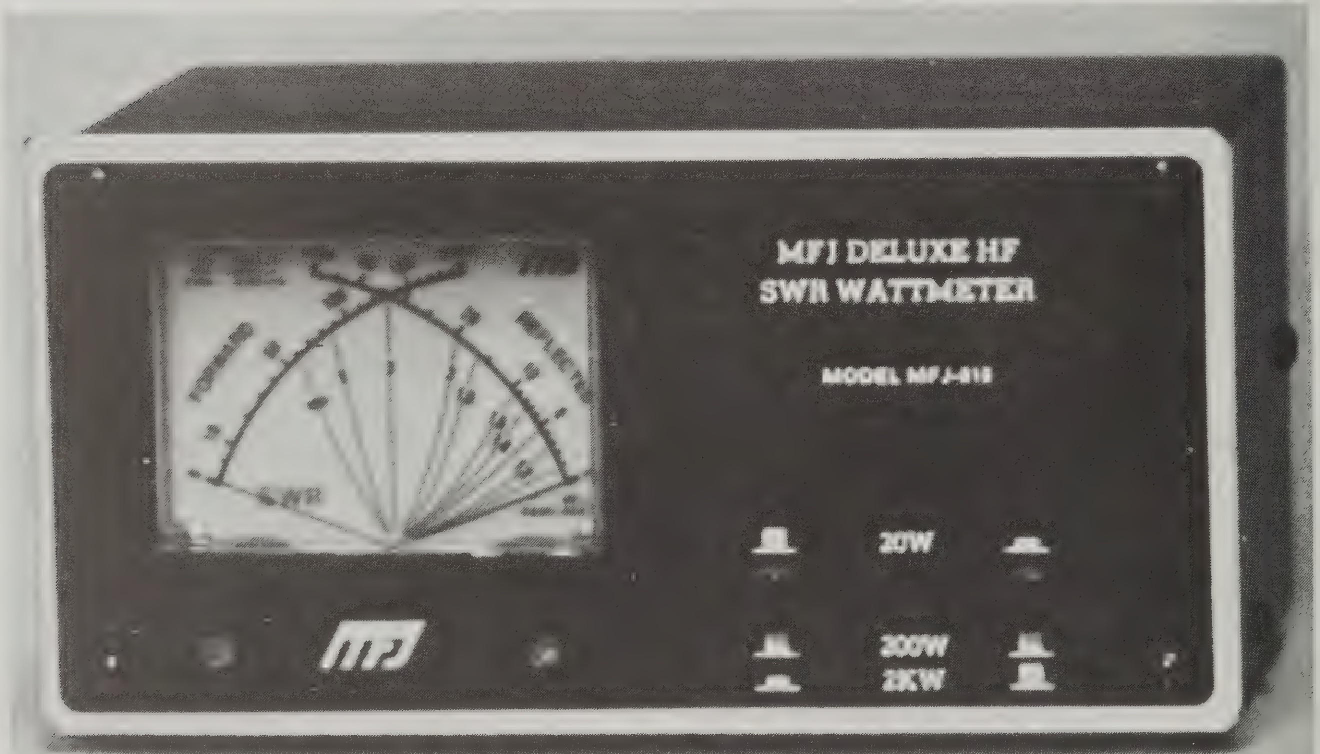


Figure 8-8 *The modern MFJ cross-needle SWR/wattmeter. This unit can be used fixed, mobile, or portable.*

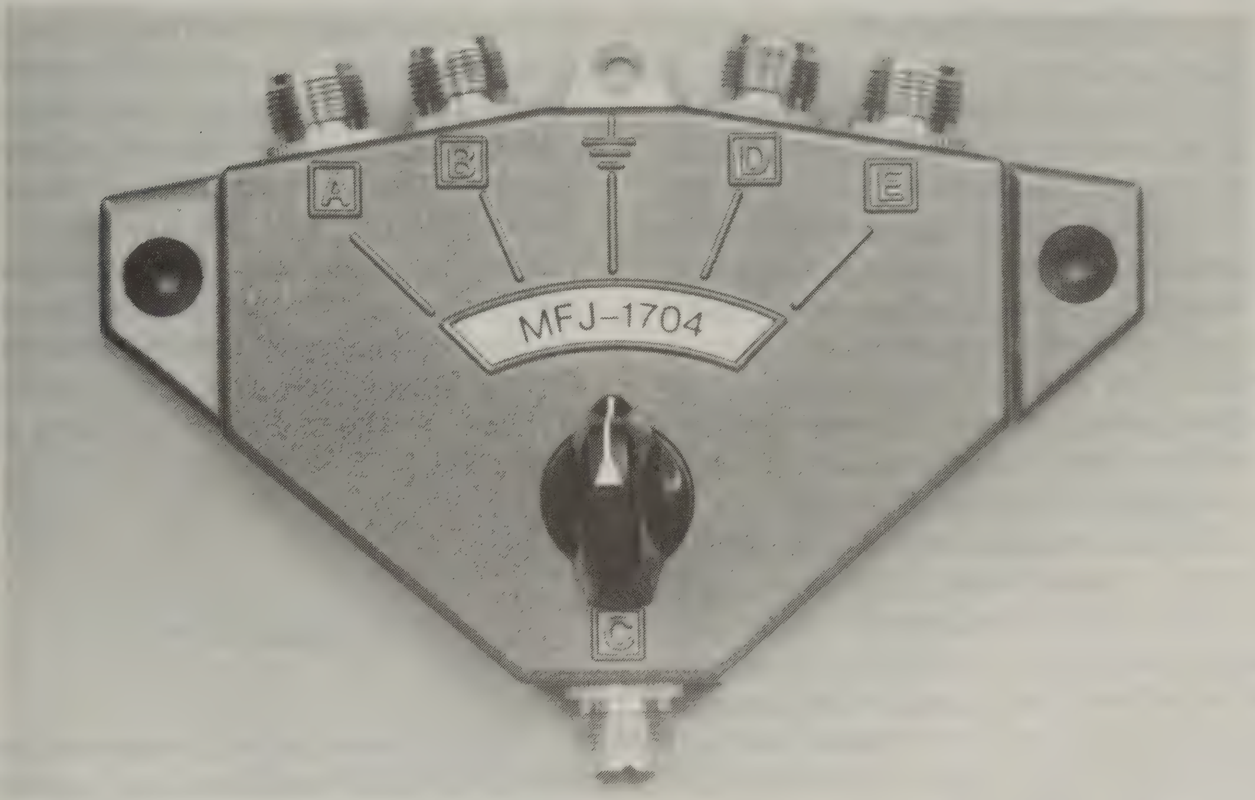


Figure 8-9 *Here is the easy way to switch between your wire antennas: MFJ's four-position, three-kilowatt-rated antenna switch.*

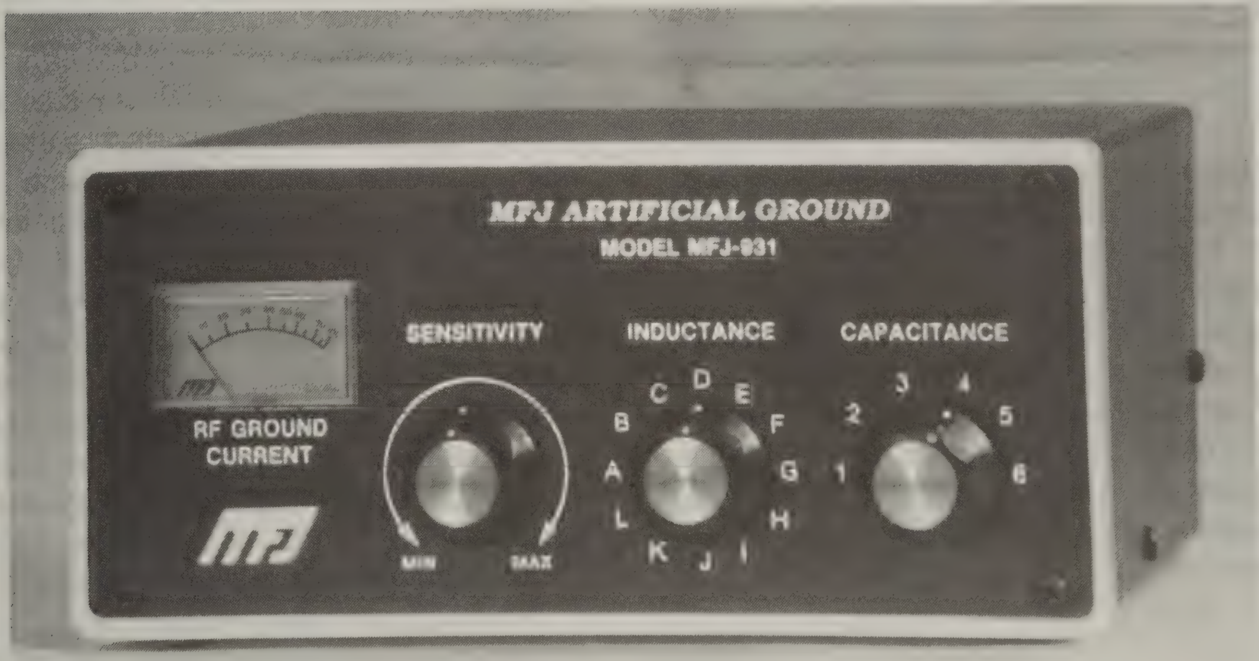


Figure 8-10 *Are electrical grounds a problem? MFJ's Model 831 is the answer.*

ICOM AMERICA, INC.

If you own an ICOM HF transceiver, this company has some complementary accessories guaranteed to make your operating more enjoyable. ICOM's Model AT-100, AT-500, and AT-150 automatic antenna tuners are real gems, especially if you use a multiband sky wire like the G5RV or Carolina Windom. You simply tune a frequency on your transceiver, and the Automatic Antenna Tuner takes over to produce a perfect SWR. That multiband convenience is great.

ICOM also manufactures a Model EX-627 automatic antenna selector that plugs directly into ICOM transceivers. When you change bands, the unit selects the proper antenna without any operator intervention. Total luxury! For more information, contact: ICOM America, Inc., 2380-116th Avenue, N.E., Bellevue, WA 98004.

PALOMAR ENGINEERS

This California-based company manufactures a small but impressive group of baluns and a clever "Tuner-Tuner." The baluns are perfect for beam or wire antenna use. Palomar's small 350-watt "PB" baluns are impressive. Several amateurs have run extensive tests on their radiation patterns, and Palomar's "PBs" always gave the best results. These little baluns are great!

Palomar's "Tuner-Tuner" is used with an antenna tuner to provide a tuning aid without transmitting a signal. They are clever, and you are assured that your rig never "sees" a high SWR. For more details on these units, contact: Palomar Engineers, Box 455, Escondido, CA 92025 (Phone 1-619-747-3343).

UNADILLA

These classic "W2AU" baluns are almost a reference in homemade antenna use. They have been employed by amateurs and military installations for over 20 years. The baluns are available for HF and VHF, in 1:1 and 4:1 ratios. For more details, contact: Antennas Etc., P. O. Box 215, Andover, ME 01810-0814 (Phone 1-617-475-7831).

The previous information may not completely cover the antenna and accessory market, but it is a good start. We trust you will find its listings, addresses, and telephone numbers an effective guide for home shopping. Enjoy!

CLOSING NOTES

This book was originally written as a small how-to-do-it tutor and dimensioning guide for assembling inexpensive wire antennas. Its objective was to present all of the basic details and guidance in one small book to which you could refer when constructing antennas and to be on the air within one or two hours thereafter. A few years later, publisher Tom Harrington of Universal Electronics, Inc. suggested an even more reader-beneficial idea: Expand the book into a full-size work with all the latest sky wires and references which would be useful to all radio amateurs. Following the book's directly-to-the-point format while retaining its "friends-helping-friends" atmosphere, we have included details on all favorite and brand new styles of antennas along with latest news on cables and baluns. The overall result is an up-to-the-minute reference on coaxial cable (e.g., polyvinyl-chloride jacketing), new antennas (e.g., the Carolina Windom), notes on baluns (there are differences), and much more.

Whether you have installed 50 wire antennas or are pursuing construction of your first sky wire, this book is your guiding aid. It is not intended as a technical study of electromagnetic radiators, but rather a simple-to-understand work for getting on the air with an impressive signal. Our only purpose is to help you enjoy today's fascinating world of amateur radio. The HF bands are hot with DX action, sunspot counts are rising every day, and two new WARC bands beckon your investigation. Come on in and join the fun!

One of the especially attractive aspects of wire antennas is their adaptability to "fit" almost any environment. There are designs for big yards with low trees and small yards with tall trees. They can be bent, angled, or sloped. They may use small wire for low visibility, or they may be heavy steel-cored wire. Most importantly, however, is they get you on the air—and that, dear friends, is the true enjoyment of amateur radio communications!

ANTENNA NOTES

ANTENNA NOTES

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ANTENNA NOTES

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THE INEXPENSIVE PATH TO SUCCESSFUL DXing

What's the least expensive and most effective way to equip your new transceiver, QRP rig, or classic transmitter and receiver setup for worldwide amateur radio communications? Use a homemade wire antenna, naturally! This book is dedicated to fulfilling that exact purpose, and it's chocked full of ready-to-use designs and dimensions on both "basic" and "gain" antennas. There is information on hidden and disguised antennas, tuners and baluns, SWR meters, noise bridges, converting any antenna's dimensions to your favorite HF band, and more—much more!

Whether you are anxious to join the action on a recently acquired WARC band, seeking a better radiator for your favorite HF band, or getting ready to put your very first signal on the air, this book is your guiding source of information. Its contents are "user oriented" rather than technical, it features large diagrams and easy-to-read text, and we're confident it will spend more time on your station's desk than collecting dust in your filing cabinet. Don't just take our word for these statements, take a look inside and see for yourself!

Dave Ingram, K4TWJ